ANALYSIS OF LAND USE AND LAND COVER CHANGE IN SOUTHERN PART OF KADUNA METROPOLIS, KADUNA STATE, NIGERIA.

BY

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DECLARATION

I declare that the work in this thesis entitled ‘’Analysis of landuse and land cover change in southern part of Kaduna metropolis, Kaduna State, Nigeria’’ was conducted by me, it has not been presented in the department or anywhere for the award of Masters Degree. All quotations and source of information are duly acknowledged by means of References.

....

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CERTIFICATION

This thesis entitled ‘’Analysis of landuse and land cover change in southern part of Kaduna metropolis, Kaduna State, Nigeria’’ by Ishaya Goje Musa meets the regulations governing the award of the degree of Master of science (GIS and Remote Sensing) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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This work is dedicated to my late brother Mr. Ibrahim M. Goje and mother Mrs. Halima M. Goje both of blessed memories. (May your Souls Rest in Peace).

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Oh Lord God Almighty, the maker of heavens and earth. There is none like you and none to be compared to you for your mercies endure forever. I will not cease to declare your wondrous works upon my life. I will forever lift up and magnify your name for making my dream a reality.

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ABSTRACT

Land use and land cover change is driven by human actions and also drives changes that limit availability of products and services for human and livestock, and it can undermine environmental health as well. Therefore, the aim of this research was to analyse land use and land cover change (LULCC) in the southern part of Kaduna metropolis. The following data were used; Landsat (4) Thematic Mapper (TM) with 30m spatial resolution of 1990, Landsat (7) Enhanced Thematic Mapper Plus (ETM +) with 30m spatial resolution of 2001 and Landsat (8) Enhanced Thematic Mapper Plus (ETM +) with 30m spatial resolution of 2014 which covered the time frame between 1990 to 2014. Erdas Imagine Software version 9.2 and ArcGIS version 10.1 were used for the analysis. The landuse and land cover distribution was determined by classifying the landuse and land cover maps into built-up land, agricultural land, vegetation land, bare surfaces and water body using supervised classification technique. An overlay analysis was carried out in order to determine the magnitude and rate of change of the classified landuses. Also, socio-economic survey was conducted to assess the perception of the farmers in respect to the loss of their farm lands due to landuse and land cover changes. The analysis of the results revealed an overall landscape change in landuse and land cover status of the area. Urban landuse witnessed an overall net change or increase of 75.56 km^2 (186.29%) with an annual growth rate of 7.76% from 1990 to 2014. While agricultural landuse being the most dominant landuse in 1990; witnessed an overall change or decrease of 54.81 km^2 (25.64%) between 1990 and 2014. Similarly, Vegetation landuse also witnessed an overall change or decrease of 13.51 km^2 (48.13%) between 1990 and 2014 and bare surfaces dropped by 18.81% between 1990 and 2014. Water body also changed or decreased by 29.23% between 1990 and 2014. However, a socio-economic survey conducted in the study area revealed 35.9% of the farmers have lost their farmlands and means of livelihood due to landuse and land cover change. In view of the findings of the research, the study recommends periodic monitoring, control and evaluation of the LULCC of the area in order to checkmate harp-hazard developments or modifications that may be detrimental to the inhabitants.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Land use and land cover dynamics are widespread and accelerating. It is a significant processes driven by human actions but also producing changes that impact humans (Agarwal, Green, Grove, Evans, and Schweik, 2002). These dynamics alter the availability of different biophysical resources including soil, vegetation, water, animal feed and others. Consequently, land use and cover changes could lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment as well. Human beings have been modifying land to obtain food, shelter and other essentials of life for thousands of years. Current rates, extents and intensities of such modifications are far greater than ever in history and continue undocumented (Eastman 1999). At times, even the agencies or body that is charge with planning and enforcement of planning rules and regulations fail to do their jobs as a result of interference from different quarters. This negligence may lead to unprecedented changes in ecosystems and environmental processes at local and regional scales. Therefore, monitoring and mediating the negative consequences of land use and land cover changes while sustaining the production of essential resources has therefore become a major priority of researchers and policy makers around the world.

Land is a specific area of the earth surface with physical entity in terms of its topography and spatial nature (Ashaye, 1987), and one of the characteristic of space that is widely recognized as significant for planning and management purposes (Anderson, Hardy, Roach and Witmer, 1976). Land is therefore, a key element for any

developmental processes that takes place on the earth surface but land in urban areas suffers unique ecological and economic pressures (Drescher, 2000), leading to a lost in its land based. Land is the most important natural resources on which all activities are based. Land use unlike geology, is seasonally dynamic and indeed is more changing.

Information on the rate and kind of changes in the use of land resources is essential for proper planning, management and to regularize the use of such resources. Knowledge about existing land use and land cover and its trend of change is essential for various reasons. Landuse data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standard are to be improved or maintained at current levels. Changes in land use can be due to urban expansion, loss of agricultural land, changes in river regimes, the effect of shifting cultivation, the spread of erosion and desertification and so on. Therefore, this requires not only the identification of features but also the comparison of subsequent data in order to recognize when valid changes has taken place.

Land cover (LC) according to Campbell (1996), refers to the physical cover of the earth including natural vegetation, crops, artificial constructions that cover the land surface On the other hand, land use (LU) refers to the actual use of the land which is the purpose for which man exploits the land cover (Omojola, 1997); land use describes the use of the land by the people usually with emphasis on the functional role of land on economic activities (Campbell, 1996): and man's activities which are directly related to the land (Anderson, Hardy, Roach and Witmer, 1976). Therefore, Land use and land cover (LULC) are treated jointly. They represent both the physical cover and the human imprints on land. Therefore, Land use-land cover (LULC) is

among the most important phenomenon of the earth's land surface (Lambin and Geist, 2001).

Population growth and rapid economic transformation has been identified as the cause of landuse change (Oyedele, 1977). According to the United Nations Press Release (2013), the current world population of 7.2 billion is projected to increase by almost 1billion people within the next twelve years, 8.1 billion in 2025 and 9.6 billion in 2050. United Nations World Population Prospects (2012), asserted that most of the population growth will occur in developing regions, which are projected to increase from 5.9 billion in 2013 to 8.2 billion in 2050. During the same period, the population of developed regions will remain largely unchanged at around 1.3 billion people. Growth is expected to be most rapid in the 49 least developed Countries, which are projected to double in size from around 900 million inhabitants in 2013 to1.8 billion in 2050 according to the same United Nations World Population Prospects (2012). More than half of global population growth between now and 2050 is expected to occur in Africa according to the same report. Africa could more than double its population by mid-century, increasing from 1.1 billion in 2013 to 2.4 billion in 2050, and potentially reaching 4.2 billion by 2100. Since it is the activities of man that constitute changes in the landuse and land cover, by implication, it means most of the landuse and land cover changes is fast occurring in developing countries of the world with Africa experiencing the fastest landuse and land cover changes.

In Nigeria, according to United Nations Press Release (2013), Nigeria population stood at 170 million and is expected to surpass that of the United States before the middle of the century, and could start to rival China at the end of the century as the second most populous country in the world. According to the Nigeria National

Bureau of Statistics (2012), the total population of citizens in Nigeria was around 166.2 million people. Today, it is estimated to have about 178.5 million people. Back in 1960, when the country declared its independence from the United Kingdom, the country recorded an estimated 45.2 million people that constitutes a change of about 268% between the year 1960 and the year 2012. The entire population of Nigeria accounts for about 2.5% of the entire earth's population. This means that about 1 out of every 40 people in the world call Nigeria their home. This growth probably account for most of the landuse and land cover changes that is prominent in all Nigerian cities.

As population increases, there is a corresponding increase in human alteration or modification due to increase in the diversity of functional activities (Ariyo, 1991). Man continued to temper with the original land cover and convert it into other landuses in order to meet his immediate needs. Where the supply of serviced land cannot meet his demand, the tendency is often the indiscriminate conversion of other landuses such as those meant for agriculture land, vegetation land, crop land, forest land, bare lands, environmental protection etc to uses that are at variance with the conceptual plans of such towns and cities (Ariyo, 1991). Therefore, the activities of man are the most driven force for landuse and land cover changes of any town or city.

Land-use change is a locally pervasive and globally significant ecological trend. (Clawson, Mari. and Stewart, 1965). notes that "three of the well-documented global changes are increasing concentrations of carbon dioxide in the atmosphere; alterations in the biochemistry of the global nitrogen cycle; and on-going land-use/land-cover change." In the United States, 121,000 km2 of non-federal lands were converted to urban development between 1982 and 1997 (Natural Resources Conservation Service 1999). Globally and over a longer period, nearly 1.2 million km2 of forest and

woodland and 5.6 million km2 of grassland and pasture have been converted to other uses during the last 3 centuries, according to Ramachandra, Bharath and Sreekantha (2002). During this same period, cropland has increased by 12 million km2. Humans have transformed significant portions of the Earth's land surface: 10 to 15 percent currently is dominated by agricultural rowcrop or urban-industrial areas, and 6 to 8 percent is pasture (Clawson, Mari. and Stewart, 1965).

Remote Sensing and Geographic Information System (GIS) technique was used for the study due to its suitability and ability to integrate several dataset together. Remote Sensing technique has already shown its value in mapping urban areas at various scales and as data sources for the analysis of land use land cover changes (Donnay, Barnsley and Longley, 2001; Batty and Howes, 2001; Herold, Scepan and Clarke, 2002).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Landuse and land cover changes is evident in Nigerian cities as with other developing nations of the world. Being one of the most urbanized Countries on the African continent with estimated urbanization rate of 3.5% annually, Nigeria has witnessed a tremendous urban expansion over the years (World Bank, 2009). Oyinloye (2013), asserted that the share of urban population out of the total population of Nigeria was less than 7% in 1931 but has continued to escalate over the years from about 10% in 1952 to 19.2% in 1991 to 48% in 2010 and it reached 50% in 2012. The above increase in urbanization rate indicated that by the year 2012, half of the population of Nigeria were already living in urban areas. This explosive increased in population has resulted in rapid human alteration or modifications of the biosphere that brought

changes in the landuse and land cover distribution of all Nigerian cities with southern part of Kaduna metropolis not an exception.

However, Landuse and land cover changes have far reaching consequences. Therefore, a modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one such aspect, but knowledge about land use and land cover has become increasingly important if the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use data are therefore needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels.

From the beginning, land use land cover status of Southern part of Kaduna metropolis remained largely unchanged until the last four decades when the area began to assume some dimension of spatial growth due to population growth and rapid economic transformation (Oyedele, 1977). As a result of the population growth of the area, the activities of man have modified the landuse and land cover status of the area. Most of the vegetation cover, bare land, and agricultural land that was conspicuous in Goni-Gora, Narayi and some eastern parts of Sabon-Tasha which were visible in 1990 (fig 4.1) have now been converted into other landuses for building of residential, roads and infrastructural developments. Similarly, the barren land around Unguwan Romi and some other parts of the study area in 1990 (fig. 4.1) has greatly reduced due to the activities of man and water bodies also shrinked as a result of developments along the water ways. Other consequences are also observable such as deteriorating

environmental quality, destruction of important wetlands, and loss of fish due to water body shrinkage and wildlife habitat are all observable in the study area.

Urban landuse on the other hand has recorded a remarkable increased in its area coverage (fig. 4.1, 4.2 and 4.3). (Oyedele, 1977) pointed out that initially, the growth of the area started in 1965 with three settlements namely: Barnawa, Kakuri and Sabon-Tasha as native hamlets whose majority of their population earn their living through farming as with most northern Nigeria cities; but asserted that the area has now grown and coalesced into one sprawling mass (fig. 4.3). The growth of the area was further substantiated by a study conducted by Akpu and Tanko (2012), on the growth of Kaduna metropolis. The results show that built-up area increased from 6,410.40hactares in 1973 to 19,611.50ha in 2009 at annual growth rate of 5.72%. The authors asserted that South part of Kaduna metropolis (The study area) is growing at an annual rate of 11.24%. This figure is however alarming and substantiates the fact that Kaduna metropolis, most importantly, southern part of Kaduna metropolis is undergoing spatial rapid changes in its landuse and land cover composition. In spite of the changes in landuse and land cover that is fast taking place in southern part of Kaduna metropolis, there is no study or research undertaken to monitor, document and analyze such changes. It has therefore become imperative to conduct a study such as this in southern part of Kaduna metropolis with a view to monitor, document and analyse the landuse and land cover changes that has taking place over time.

A review of previous relevant studies shows that only limited studies have been conducted in the study area in spite of the continual landuse and land cover changes. Njungbwen and Njungbwen (2011) studied urban expansion and loss of agricultural land in Uyo, Akwa Ibom state using Geographic Information System (GIS) and Remote Sensing techniques. Aerial photographs of 1969-2001 and Quick Bird

satellite imagery of 2004 were used. Their results showed that the average annual rate of urban growth rose from 4.48% between 1978 and1988, to 8.57% between 1988 and 2001 and rose to 5% between 2001 and 2004, The results also indicated that the loss in agricultural land increased from 0.4% between 1978-1988, to 0.46% between 2001-2004.

Similarly, Zubair, (2006) analysed landuse /Land cover change in Ilorin between 1972 and 2001 using Landsat imageries. The result of the work shows a rapid growth in built-up land between 1972 and 1986 while periods between 1986 and 2001 witnessed a reduction in this class. Also, Momoh and Adeofun (2005) used Geospatial Information System to asses urban agricultural land use changes in Bukuru Jos. Landsat enhanced thematic mapper (ETM+) with a higher multispectral spatial resolution of 30 m were used between 1986 and 200. The results revealed that about 68% of agricultural land in the area was lost to urban development between 1986 and 2002. This shows that urban expansion was increasing, whereas, agricultural land was decreasing.

Ishaya, Ifatimehin and Okafor (2008) analysed the rate of urban expansion and loss of vegetation cover in Kaduna town using Geographic Information System (GIS) and Remote Sensing techniques over a period of 11years (1990 to 2000). The authurs used Landsat TM of 1990 and Landsat TM of 2000. The results showed that built-up area was expanding at about 167.86 hectares annually while vegetation cover was declining at a faster rate of 297.5 hectares annually. The results also revealed that bare land, a component of urban expansion also increased by 183.5%.

Akpu and Tanko (2012) studied the rate and pattern of the Spatio-Temporal Growth of Kaduna Metropolis between 1973 and 2009 using GIS and Remote Sensing

technique. They used Landsat MSS imagery obtained in 1973; Landsat TM captured in 1990; Landsat ETM+ acquired in 2001 and Nigeriasat-1 image of 2009. Visual interpretation method was used to sort the various datasets into landuse and land cover classes. The results revealed that the built-up area increased from 6,410.4ha in 1973 to 19,611.5ha in 2009 at the rate of 5.72% per annum within the study period. The result also showed that the area towards the southern part of the River Kaduna was growing at a higher rate 11.24%.

Chigbu, (2011). Analysed landuse and land cover changes in Aba urban area between 1991, 2000 and 2005 using medium resolution satellite imageries (Landsat ETM+ of 2000 and and Nigeria Sat-1 of 2005). The results reveals that from 1991 to 2005, water bodies increased from 15.1% to 22.1% and to 22.4% due partly to increasing activities within and around the water ways, built-up area increased from 21.7% to 26.8% to 36.5%. While Odeh (2014), conducted a research using GIS and Remote Sensing technique to study the impact of urban expansion on agricultural lands in urban Zaria and its environs between 1970-2009 a) The author used LandSat Multi-Spectral Scanner (MSS) images 1973, LandSatThematic Mapper (TM) of 1990, LandSat Enhanced ThermaticMapper(ETM) of 1999 and NigeriaSat-1 Image of 2009. The results showed that built-up areas have grown considerably from 14.51km^2 in 1973 to 37.13km^2 in 2009 and agricultural lands have reduced significantly from 442.58km^2 in 1973 to 204.21km^2 in 2009.

Although, all the previous literature review shows there has been several studies on urban growth that was undertaken in Kaduna metropolis using GIS and Remote Sensing technique; but none was undertaken to analyse landuse and land cover changes that has taken place over time in southern part of Kaduna metropolis. For

instance, Ishaya, Ifatimehin and Okafor (2008), analysed the rate of urban expansion and loss of vegetation cover in Kaduna town over a period of 11years (1990 to 2000). Likewise Akpu and Tanko (2012), studied the rate and pattern of the Spatio-Temporal Growth of Kaduna Metropolis between 1973 and 2009. This study therefore, seeks to analyse the landuse and land cover changes that has taken place in the southern part of Kaduna metropolis between 1990 and 2014 using GIS and Remote Sensing technique. The study sought answers to the following questions;

1. What was the extent of land use and land cover distribution in 1990, 2001 and 2014 in southern part of Kaduna metropolis?
2. What is the magnitude and rate of change in land use and land cover in 1990, 2001 and 2014 in southern part of Kaduna metropolis?
3. To what extent is urban landuse responsible for loss in other landuses in the study area between 1990 and 2014?
4. What are the implications of landuse and land cover change on the farmers in the study area?

1.3. AIM AND OBJECTIVES OF THE RESEARCH

The aim of this research is to map out land use and land cover distribution in the southern part of Kaduna metropolis.

The objectives of the research are to:

i. Characterize the landuse and land cover of the area in 1990, 2001 and 2014.
ii. determine the magnitude and rate of change of land use and land cover of the area between 1990 and 2014.

iii. determine the extent to which urban landuse encroached into other landuses in the study area within the study period.

iv. examine the perception of the farmers on the implications of landuse and land cover change in the study.

1.4 THE SCOPE OF THE STUDY

The study area covered the whole of southern part of Kaduna metropolis taking River Kaduna as a boundary to the north and extending southwards to cover the settlements south of the River such as; Barnawa, Kakuri, Sabon-Tasha, Marraban-Rido, Gonin-Gora, Unguwan Musa, Unguwan Romi, Kakau, Kamazo, Kudansa, Makera, Television, Unguwan Yelwa, Narayi, NNPC, Unguwan Sunday, Unguwan Sale, Kudansa etc. The study area has a total land area of 319.16km^2. In terms of content, the study analysed and the land use and land cover changes that has taken place in the study area over a period of 24 years (1990 – 2014). The study examined the magnitude and rate of change in land use and land cover distribution between 1990 and 2014. The extent to which urban landuse encroached into other landuses and the implications of landuse and land cover change on the farmers was also examined.

1.5 JUSTIFICATION

The earth's surface is changing as a result of natural phenomena or human activity, for example, wildfires, lightning strikes, storms, pests, agro-forestry, agricultural expansion, social, economic, technological, historical factors and urban growth and the like (Borak, Lambin & Strahler, 2000). Population growth is responsible for most of the changes in landuses due to diversity in functional activities. The population of southern part of Kaduna metropolis recorded an up-surge during the last three decades

as a result of migration. The area is perceived to be a place where one could have a better life due to its unique nature and geographical location (Oyedele, 1977). It is a place where both private and public sector participation thrive. This, however, accounted for the rapid socio-economic transformation that triggers the movement of people to the area and consequently the growth of the area. People migrate to the area to seek for better work opportunities, higher salaries, better services, and better lifestyles. The perceived better conditions attracted people from far and near to mainly seek and improve their economic positions. As the population increased, so also there is increase in the diversity of functional activities leading to more alterations or modifications that brought changes in the landuse and land cover composition of the area.

Due to negative consequences of landuse and land cover change, during the past decades, several international interdisciplinary research projects have been initiated on these issues including the International Geosphere-Biosphere Programme Committee on Global Change (IGBP, 1988) and the Land Use and Cover Change program (Messerli, 1997). Both of these projects indicated the need to construct an updated and accurate database concerning these changes, their meaning, their pace and the explanatory factors prompting their appearance (Mather, 1999). The ability to recognize that change is a key requirement for the accurate analysis of LULCC (Lambin, Baulies, Bockstael, Fischer, Krug, Leemans, Moran, Rindfuss, Sato, Skole and Vogel, 1999) instead of an improvement in the spatial resolution of image data and a detailed ground survey.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

The chapter presents conceptual framework and literature review. Concept of landuse and land cover in relation to change, detection technique etc are discussed in this chapter. Theories and models associated with landuse and land cover was discussed since quite a number of such theories and models have evolved but only the theories and models that are applicable to this study are discussed. Geographic Information System (GIS) and Remote Sensing are also discussed under this chapter.

2.2. CONCEPTUAL FRAMEWORK

2.2.1. Landuse and Land Cover

Many existing information systems are mixing land cover and land use where natural and semi-natural vegetation are described in terms of land cover and agricultural and urban areas in terms of land use. However, these are two different issues and distinction between land cover and land use is fundamental though often ignored or forgotten (Di Gregorio & Jansen, 1997). Confusion and ambiguity between these two terms lead to practical problems, particularly when data from the two different dimensions need to be matched, compared and/or combined.

Land cover corresponds to a physical description of space, the observed bio-physical cover of the earth's surface (Di Gregorio & Jansen, 1997). It is that which overlays or currently covers the ground. This description enables various biophysical categories to be distinguished. Basically, areas of vegetation (trees, bushes, fields, lawns), bare soil (even if this is a lack of cover), hard surfaces (rocks, buildings) and wet areas and

bodies of water (sheets of water and water courses, wetlands). This definition has impacts on development of classification systems, data collection and information systems in general. It is said that Land Cover is "observed". This means that observation can be made from various "sources of observation" at different distances between the source and the earth's surface: the human eye, aerial photographs, satellite sensors.

On the other hand, for landuse, various approaches are proposed into the literature. Two main “schools” may be distinguished. Land use in terms of *functional dimension* corresponds to the description of areas in terms of their socio-economic purpose: areas used for residential, industrial or commercial purposes, for farming or forestry, for recreational or conservation purposes, etc. Links with land cover are possible; it may be possible to infer land use from land cover and conversely. But situations are often complicated and the link is not so evident.

Another approach, termed sequential, has been particularly developed for agricultural purposes. The definition is a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources. For example a sequence of operations such as ploughing, seeding, weeding, fertilizing and harvesting (Mucher, Stomph and Fresco, 1993) observed. For example, it is often difficult to decide if grasslands are used or not for agricultural purposes. The information coming from the source of observation may not be sufficient and may require additional information. In the case of agricultural use, farmers may bring information, for example if cattle are present or not, if they are grazing. It is also possible to use characteristics on the spot indicating the presence or absence of cattle. For the functional approach, inference from land cover may be helpful. For the

sequential approach, a more exhaustive recording of various attributes will be needed, for example a multi-temporal approach. In the following, land use will be understood as functional.

Interrelationship between land cover and land use exist. A very useful comparison can be made with approaches for classifying commodities where objects are described according to the material they are made of and the function they serve. It is sometimes possible to determine functional aspect from biophysical aspect (Duhamel and Vidal, 1999). A parcel of land covered by a field of wheat can reasonably be associated with agricultural use. Similarly, it is possible to infer biophysical aspect from functional aspect. An area used for forest production can reasonably be assumed to correspond to a biophysical class of the "tree" type.

However, for others, one biophysical category may correspond to a large number of functional categories. Areas of grass may, for example, correspond to a lawn in an urban environment, an airport runway, a sown meadow, rough pasture, a golf course or even a church roof in Iceland. Conversely, one and the same functional class may cover several biophysical categories: for example, a residential area consists of lawns, buildings, tarmac roads, trees and bare soil. There are methodological and technical arguments in favour of the systematic separation of the two approaches. Even if it is difficult to justify when analysing both, user needs and the possible costs of simultaneously acquiring, using and managing data obtained through separate approaches, importance of the knowledge for the two dimensions may be illustrated with the following example adapted from (Lund, 1998).

2.2.2. Landuse and land cover change

Landuse and land cover changes LULCC represent the changes that occur over the land cover as a result of human landuses (Omojola, 1997). Landuse and land cover change is a global phenomenon and probably the most significant regional human disturbance to the environment. (Clawson, Mari and Stewart, 1965) asserted that "Land Use and Land Cover changes occur at all scales, from global to regional to local to microscopic ones. Changes can have dramatic, cumulative impacts due to the impacts on land management practices, economic health, and sustainability, and social, and political processes. Therefore, land Use and land Cover changes information is of concern to a wide variety of stakeholders, scientists, and citizens. Igbokwe (2010) opined that landuse and land cover information should form part of the environmental data, which are kept in the form of inventories and infrastructures in many advanced and emerging economics.

Therefore, information on land cover and landuse change are of special value integrating the temporal dimension. This is of overall interest for both politicians for the evaluation of land related policy measures and for the research community, discovering the underlying causes and consequences. Land cover and land use change is commonly divided into two broad categories (Stott and Haines-Young, 1996; Alun and Clark, 1997; Baulies and Szejwach, 1997) conversion and modification. Conversion refers to a change from one cover or use category to another (e.g. from forest to grassland) while Modification represents a change within one landuse or land cover category (e.g. from rain fed cultivated area to irrigated cultivated area) due to changes in its physical or functional attributes. The pure land cover and land use information gains a significant added value through the analysis, identification and description of ongoing processes.

2.2.3. Change Detection Techniques

After Landsat satellite system was launched in 1972, wide ranges of data have been provided (Williams, Goward & Arvidson 2006). The availability of a large archive of data leads to the development and evaluation of many digital change detection techniques and methods for analyzing and detecting LULC changes (Dewidar, 2004). Various methods have been extensively reviewed and provided with excellent descriptions and comprehensive summaries (Singh, 1989; Xiubin, 1996; Lu, Mausel, Brondízio and Moran, 2004; Corresponding, Jonckheere, Nackaerts, Muys and Lambin, 2004). Basically, there are two categories of change detection methods: pre-classification and post- classification change detection techniques (Lu, Mausel, Brondízio and Moran, 2004).

2.2.3.1 Pre-classification Techniques

The pre-classification techniques, also known as binary change or non-change information detecting techniques, include various techniques that directly use the multiple dates of satellite imagery to generate ‘‘change’’ vs. ‘‘no-change’’ maps. Many pre-classification techniques have been used and compared to assess and identify LULCC changes such as, Image Differencing (ID) (Hayes and Sader, 2001), Improved Change-Vector Analysis (Green, Kempka & Lackey 1994), Band Image Differencing (Chavez and MacKinnon, 1994), RGB-NDVI Change Detection Method (Wen and Yang, 2009; Geun-Won, Young-Bo and Jong-Hyun, 2003; Johnson and Kasischke, 1998), Spectral Change Vector Analysis (Wen and Yang, 2009), Principal Component Differencing (PCD), Change Vector Analysis (CVA)(Chen, Gong, He, Pu, and Shi, 2003) and others. The basic premise in these techniques is measuring the nature of changes, which means changes in the features of interest that will result changes in radiance or reflectance values (Lu, Mausel, Brondízio and Moran, 2004).

Most of the preclassification techniques are identified as the most accurate change detection techniques because, they are straight forward, effective for identifying and locating change and are easy to implement (Sunar, 1998). However, three aspects are critical for pre-classification techniques: selecting suitable thresholds or vegetation index to identify the changed areas, being sensitive to mis registration of pixels and they cannot provide details of the nature of change or provide a matrix of change information (Lu, Mausel, Brondízio and Moran, 2004).

2.2.3.2 Post-Classification Comparison Technique

The post-classification comparison has been proven to be the most popular approach in change detection analysis (Foody 2002b). This approach is based on rectification of more than one classified image; where it involves the classification of each of the images independently, then the thematic maps are generated, followed by a comparison of the corresponding labels or themes to identify areas where change has occurred. There are several advantages to this technique: it minimizes sensor, atmospheric, and environmental differences because data from two dates are separately classified, thereby minimizing the problem of normalizing for atmospheric and sensor differences between two dates and it provides a complete matrix of land cover change when using multiple images (Lu, Mausel, Brondízio and Moran, 2004; Naumann and Siegmund, 2004; Teng, Chen, Cheng and Lo, 2008). A series of "from-to" matrixes can be built by comparing on a pixel by pixel basis, and these matrices include pixel conversion matrix, percentages conversion matrix, and area conversion matrix. However, results derived from this method are only as accurate as the individual classification images themselves (Corresponding, Jonckheere, Nackaerts, Muys and Lambin, 2004; Civco, Hurd, Wilson, Song and Zhang, 2002). Furthermore, this method could lead to wrong results especially when using multi-date or multi-

sensor images due to the differences in the radiometric characteristics of the images from which thematic maps were obtained (Foody, 2002a; Foody, 2002b)

2.3. Models of Land-Use and land Cover Change

This section examines myriad LULCC modelling approaches and discusses their strengths and weaknesses of nine broad, partly overlapping, categories of models.

2.3.1. Equation-Based Models

Most models are in some way mathematical, but some are especially so in that they rely on equations that seek a static or equilibrium solution. The most common mathematical models are sets of equations based on theories of population growth and diffusion that specify cumulative land-use/cover change over time (Sklar and Costanza 1991). More complex models, often grounded in economic theory, employ simultaneous joint equations (Kaimowitz and Angelsen 1998). A variant of such models is based on linear programming (Weinberg, Kling, and Wilen 1993), potentially linked to GIS information on land parcels (Longley, Higgs, and Martin 1994). A major drawback of such models is that a numerical or analytical solution to the system of equations must be obtained, limiting the level of complexity that may practically be built into such models.

2.3.2. System Models

System models represent stocks and flows of information, material, or energy as sets of differential equations linked through intermediary functions and data structures (Gilbert and Troitzsch 1999). Time is broken into discrete steps to allow feedback. Human and ecological interactions can be represented within these models, but they

are dependent on explicit enumeration of causes and functional representation, and they accommodate spatial relationships with difficulty (Sklar and Costanza 1991).

2.3.3. Statistical Techniques

Statistical techniques are a common approach to modelling land-use/cover change, given their power, wide acceptance, and relative ease of use. They include a variety of regression techniques applied to space and more tailored spatial statistical methods (Ludeke, Maggio, and Reid, 1990). Unless they are tied to a theoretical framework, statistical techniques may downplay decision making and social phenomena such as institutions. Successful examples of combining theory and statistics are provided by spatial econometrics (Chomitz and Gray, 1996; Leggett and Bockstael 2000).

2.3.4. Expert Models

Expert models combine expert judgment with non frequents probability techniques such as Bayesian probability or Dempster-Schaefer theory (Eastman 1999) or symbolic artificial intelligence approaches such as expert systems and rule-based knowledge systems (Lee, Flamm, Turner, Bledsoe, Chandler, DeFerrari, and Gottfried, 1992). These methods express qualitative knowledge in a quantitative fashion that enables the modeller to determine where given land uses are likely to occur. It can be difficult to include all aspects of the problem domain, however, which leaves room for gaps and inconsistencies.

2.3.5. Evolutionary Models

Within the field of artificial intelligence, symbolic approaches such as expert systems are complemented by a biologically inspired evolutionary paradigm. Exemplars of this field, such as artificial neural networks and evolutionary programming, are

finding their way into LUCC models (Mann and Benwell, 1996). In brief, neural networks are silicon analogs of neural structure that are trained to associate outcomes with stimuli. Evolutionary programming mimics the process of Darwinian evolution by breeding computational programs over many generations to create programs that become increasingly able to solve a particular problem.

2.3.6. Cellular Models

Cellular models (CM) include cellular automata (CA) and Markov models. Each of these models operates over a lattice of congruent cells. In CA, each cell exists in one of a finite set of states, and future states depend on transition rules based on a local spatiotemporal neighbourhood. The system is homogeneous in the sense that the set of possible states is the same for each cell and the same transition rule applies to each cell. Time advances in discrete steps, and updates may be synchronous or asynchronous (Hegselmann 1998). More general versions of CA use nonlocal neighbourhoods (Takeyama and Couclelis 1997) and graph networks (O'Sullivan 2001).

In Markov models, cell states depend probabilistically on temporally lagged cell state values. Markov models may be combined with CA for LUCC modelling as evidenced by joint CA Markov models (Balzter, Braun and Kohler 1998; Li and Reynolds 1997). Cellular modeling methods underlie many LUCC models. Tobler (1979) was one of the first to suggest the use of CM to model geographical processes. This was followed by GIS research that applied CM, particularly CA, to a number of research questions (Cecchini and Viola 1990). Sophisticated CA models of ecological processes exist for rangeland dynamics (Li and Reynolds 1997), species composition (Silvertown, Holtier, Johnson and Dale, 1992), forest succession (Alonso and Sole

2000), global land-use/cover change in response to climate change (Alcamo 1994), and a host of other biological phenomena (Ermentrout and Edelstein-Keshet 1993). Many CM inductively assume that the actions of human agents are important, but do not expressly model decisions. Others explicitly posit a set of agents coincident with lattice cells and use transition rules as proxies to decision making. These efforts succeed when the unit of analysis is tessellated, decision-making strategies are fixed, and heterogeneous actors are affected by local neighbours in a simple, well-defined manner. A good example is modelling residential choice and land use in urban areas, where actors are assumed, for analytical simplicity, to be evenly arrayed, such as in homes, and their decision making stems from interactions with immediate neighbours (Hegselmann 1998).

Other work loosens the tessellation of actors to make more realistic models (Portugali, Benenson. and Omer, 1997). When actors is not tied to location in the intrinsic manner of CA cells, however, there may be a problem of *spatial orientedness* (Hogeweg 1988), the extent to which neighbourhood relationships do not reflect actual spatial relationships. Remedy lies in techniques that have non uniform transition rules and can dynamically change the strength and configuration of connections between cells. As these characteristics lie beyond the capacities of rigidly defined CA, the pure, traditional CA method may not be broadly suited to model land-use/cover change. A LUCC model may require multiple mobile agents ranging widely over space, agent heterogeneity, agents organized among institutions and social networks, or agents that control large and varying portions of space. In sum, cellular models have proven utility for modelling ecological aspects of land-use/cover change, but they face challenges when incorporating human decision making. It is necessary to use complex hierarchical rule sets to differentiate between the kinds of decision

making that apply to groups of cells, such as local land tenure structure (White and Engelen 2000). While effective, these deviations from generic cellular automata come at the potential cost of moving away from the advantages of the generic approach. In particular, “in order to converse with other disciplines, from biology and physics to chemistry, it may be necessary that the form of CA preserve as many features of strict and formal CA models as possible” (Torrens and O'Sullivan, 2001).

2.3.7. Hybrid Models

Hybrid models combine any of the above-mentioned techniques, each of which is a fairly discrete approach unto itself. A prime example is estuarine land-use and land cover transition modelling that has an explicit, cellular model tied to a system dynamics model (Costanza, Sklar and Day, 1986). Another similar combination is DELTA, which integrates sub models of human colonization and ecological interactions to estimate deforestation under different immigration and land management scenarios (Southworth, Dale and O'Neill, 1991). Other examples that combine statistical techniques with cellular models and system models include larger-scale models such as GEOMOD2 (Hall, Tian, Qi, Pontius and Cornell, 1995), the CLUE family (Veldkamp and Fresco 1996), and endangered species models developed at the Geographic Modelling Systems Lab at the University of Illinois (Trame, Harper, Aycrigg, and Westervelt, 1997).

A distinct variant of hybrid models is dynamic spatial simulation (DSS), which portrays the landscape as a two-dimensional grid where rules represent the actions of land managers based on factors such as agricultural suitability (Gilruth, Marsh, and Itami, 1995). Dynamic spatial simulation typically does not represent heterogeneous actors, institutional effects on decision making, or multiple production activities.

However, due to their ability to represent individual decision making and temporal and spatial dynamics, they represent an important advance over previous models (Lambin 1994). The orientation toward individual decision making in DSS—that some form of land managers act over a landscape—is shared by agent-based models.

2.3.8. Agent-Based Models

Where cellular models are focused on landscapes and transitions, agent-based models focus on human actions. Agents are the crucial component in these models. Several characteristics define agents: they are autonomous, they share an environment through agent communication and interaction, and they make decisions that tie behaviour to the environment. Agents have been used to represent a wide variety of entities, including atoms, biological cells, animals, people, and organizations (Conte, Hegselmann, and Terna 1997). Autonomy means that agents have control over their actions and internal state in order to achieve goals. Woolridge (1999) defines intelligent agents as being able to act with flexibility, which implies that agents are goal-directed and capable of interaction with other agents and a common environment, meant in a wide sense as anything outside of the agents.

In a LUCC context, a shared landscape where the actions of one agent can affect those of others is likely to be the unifying environment. A land market is another example of an important environment through which agents interact. Agents must act according to some model of cognition that links their autonomous goals to the environment through their behaviour. The term cognition ranges in applicability to relatively simple stimulus-response decision making to the point where actors are proactive, take initiative, and have larger intentions. At a minimum, an autonomous agent needs strategies that allow it to react to changes in environment, given the

importance of the environment to goals and actions. Reaction can be scripted and still be considered a cognitive model in a narrow sense as long as the agent can respond to changes (Russell and Norvig, 1995).

Beyond pure reaction, some of the most well-developed formal models of human decision making are based on rational choice 12 theory. These models generally assume that actors are perfectly rational optimizers with unfettered access to information, foresight, and infinite analytical ability. These agents are therefore capable of deductively solving complex mathematical optimization problems in order to maximize their well-being and can balance long-run vs. short-run payoffs even in the face of uncertainty. While rational choice models can have substantial explanatory power, some of the axiomatic foundations of rational choice are contradicted by experimental evidence, leading prominent social scientists to question the empirical validity of rational choice theory (Selten 2001).It is an open question whether models of perfect rationality are appropriate for agent-based models applied to land-use/cover change, given the importance of spatial interdependencies and feedbacks in these systems. For instance, if the value of an action to every perfectly rational agent depends on both her actions and those of her neighbours, then she faces a high-dimensional, fully recursive programming problem if she strategically seeks to anticipate the actions of her neighbours. Recognition of the complex environment in which human decision making occurs has resulted in a movement toward agent-based models that employ some variant of bounded rationality (Gigerenzer and Todd 1999; Simon 1997).

2.3.9. Multi-Agent Systems for Land-Use/Cover Change

The exploration of modelling thus far has raised three key points (Gigerenzer and Todd 1999; Simon 1997). First, of the host of methods used to model land-use/cover change, dynamic spatial simulation offers a promising degree of flexibility. Second, as noted above, cellular models successfully replicate aspects of ecological and bio geophysical phenomena, but they may not always be suited to modelling decision making. Third, as explored more fully below, agent-based modelling is a promising means of representing disaggregated decision making. When all three points are taken together, they suggest the use of a dynamic, spatial simulation-like MAS/LUCC model that consists of two components. The first is a cellular model that represents bio-geophysical and ecological aspects of a modelled system.

The second is an agent-based model to represent human decision making (Conte, Hegselmann, and Terna 1997).. The cellular model is part of the agents' environment, and the agents in turn act on the simulated environment. In this manner, the complex interactions among agents and between agents and their environment can be simulated in a manner that assumes equilibrium conditions. Rather, equilibrium or transient but reoccurring patterns emerge through the simulated interactions between agents and their environment.

2.4. LITERATURE REVIEW

2.4.1. Review of previous studies on landuse and land cover

In order to highlight the importance of RS and GIS in urban studies, an overview of previous studies was examined both at global, continental and at regional perspective in order to assess how useful and effective is the method of Remote Sensing and GIS technique in monitoring changes on the environment and the landscape. For instance, Chigbu, (2011). Analysed landuse and land cover changes in Aba urban area between 1991, 2000 and 2005 using medium resolution satellite imageries (Landsat ETM+ of 2000 and and Nigeria Sat-1 of 2005). The results reveals that from 1991 to 2005, water bodies increased from 15.1% to 22.1% and to 22.4% due partly to increasing activities within and around the water ways, built-up area increased from 21.7% to 26.8% to 36.5%. Unlike river and built-up area, there is a significant disparity and trend in vegetation cover due to rapid urbanization and socio-economic activities. Thus, vegetation cover decreased from 63.2% to 51.1% in 2000 and in 2005, it further decreased to 41.1%.

In a similar manner, Zubair, (2006) analysed landuse /Land cover change in Ilorin between 1972 and 2001 using Landsat imageries. The result of the work shows a rapid growth in built-up land between 1972 and 1986 while periods between 1986 and 2001 witnessed a reduction in this class. It was also observed that change by 2015 may likely follow the trend in 1986/2001. Many projects were embarked upon after creation of the state and falls within the oil boom era of 1970s. But reduction between 1986-2001

atributed of what the researcher called austerity measures known as SAP introduced into the country at the period to restore the country economy.

While, Akpu and Tanko (2012) studied the rate and pattern of the Spatio-Temporal Growth of Kaduna Metropolis between 1973 and 2009 using GIS and Remote Sensing technique. They used Landsat MSS imagery obtained in 1973; Landsat TM captured in 1990; Landsat ETM+ acquired in 2001 and Nigeriasat-1 image of 2009. Visual interpretation method was used to sort the various datasets into land use/cover classes. The built-up area was extracted and the rates of growth between the periods (1973-1990; 1990-2001 and 2001-2009) were ascertained. The built-up area for the four time periods were overlaid in order to derive the urban growth. The Shanoon's entropy technique was adopted to determine the extent of landscape disorganization or pattern of growth. The results revealed that the built-up area increased from 6,410.4ha in 1973 to 19,611.5ha in 2009. The city was growing at the rate of 5.72% per annum within the period studied. The result also showed that the area towards the southern part of the River Kaduna was growing at a higher rate 11.24% compared with the northern part, however, the difference in entropy was higher for the northern zone.

Ramachandra, Bharath and Sreekantha (2002) used an integrated approach of remote sensing and spatial metrics with gradient analysis to identify the trends of urban land changes in Indian metropolis using Remote Sensing and Geographic Information System technique. The results indicated a significant increase in urban built-up area during the last four decades. Landscape metrics indicates the coalescence of urban areas occurred

during the rapid urban growth from 2000 to 2009 indicating the clumped growth at the boundary region with convoluted shapes.

Abbas and Arigbede (2011) also conducted a study in Zaria to determine the changes in landuse/landcover between 1985 and 2005 with a view to providing database for future planning. Landsat, Spot and digital globe imageries for 1985, 1995, and 2005 respectively were used for the analysis. The results showed that built-up areas increased from 2.3% in 1985 to 36.4% in 2005, water body decreased from 22.5% in 1985 to 6.5% in 2005 while cultivation decreased from 44% in 1995 to 40% sending a bad signal of imminent food crisis if not checked.

Goetzke and Broun 2003 analysed Landsat images between 1975 and 2005 over north Rhine- Westphalia in Germany, the need for the analysis being the result of urban sprawl and growing human population, which had induced land consumption in the area. They used unsupervised classification to group the classes. The result showed that grassland and agricultural land had been used up. Nathawat and Pandy (2006) mapped the Land use/ Land cover (LULC) of Panchkuta, Ambala and Yamunanger districts in India. They observed that the heterogeneous climate and physiographic conditions in these districts have resulted in the development of different LULC. The digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purposes. The hilly regions exhibit fair development of reserved forest. The implication is that LULC pattern in the area is generally controlled by agro-climate conditions, ground water potentials and a host of other factors.

Njungbwen and Njungbwen (2011) studied urban expansion and loss of agricultural land in Uyo, Akwa Ibom state using Geographic Information System (GIS) and Remote Sensing techniques. Aerial photographs of 1969-2001 and Quick Bird satellite imagery of 2004 were used. Their results showed that the average annual rate of urban growth rose from 4.48% between 1978 and1988, to 8.57% between 1988 and 2001 and rose to 5% between 2001 and 2004, The results also indicate that the loss in agricultural land increased from 0.4% between 1978-1988, to 0.46% between 2001-2004. Therefore, agricultural lands continually dropped during the period while the built-up land increased. They finally concluded that loss of agricultural land brought in hunger and poverty in the area. In like manner, Odeh (2014), conducted a research using GIS and Remote Sensing technique to study the impact of urban expansion on agricultural lands in urban Zaria and its environs between 1970-2009. The author used LandSat Multi-Spectral Scanner (MSS) images 1973, LandSatThematic Mapper (TM) of 1990, LandSat Enhanced ThermaticMapper(ETM) of 1999 and NigeriaSat-1 Image of 2009. The results showed that built-up areas have grown considerably from 14.51km^2 in 1973 to 37.13km^2 in 2009 and agricultural lands have reduced significantly from 442.58km^2 in 1973 to 204.21km^2 in 2009.This indicates an increase in the built-up areas and a decrease in agricultural land.

2.4.2. Application of Remote Sensing and GIS

Remote sensing is defined as the science of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation (Lillesand and Kieffer, 2004). Since the launch of Landsat-1, the first Earth resource satellite in 1972, remote sensing has become an increasingly important tool for the inventory, monitoring and management of

earth resources. The increasing availability of information products generated from satellite imagery data has added greatly to our ability to understand the patterns and dynamics of the earth resources system at all scales of inquiry. A particular important application of remote sensing is the generation of land use land cover maps from satellite imagery. Compared to the terrestrial survey and basic aerial pho-interpretation, land-use mapping using satellite imagery has the advantage of low cost, large area coverage, repetitive and computability (Franklin, 2001). Consequently, land-use information products obtained from satellite imagery such as land-use maps, data and GIS layers have become an essential tool in many operational programs involving land resource management.

The integration of GIS and Remote Sensing therefore has been widely recognized and applied as a powerful and effective tool in urban studies; as this have been used in determining urban growth pattern and landuse changes and quantifying and accounting for urban growth (Amjed, Rahim, Butt and Tayyab, 2010; Emmanuel, Duncan and Uwem, 2006). This is because GIS facilitates the storage and access to diverse datasets; remotely sensed data are important input to GIS; and for many applications. Remote Sensing have been employed to update GIS layers by simply overlaying several layers of information, and GIS has facilitated the integration and analysis of diverse datasets through the application of a virtually unlimited number of forms of spatial data analysis inherent in GIS (Anji, 2008). Consequently, the use of RS and GIS had provided a means of mapping and quantifying spatial changes in landuse and land cover.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1. INTRODUCTION

This chapter present the general physical background of southern part of Kaduna metropolis and the method adopted for data collection and analysis for this studies. The general topology of the area such as drainage, soil, relief as well as weather, climate and economic activities and population of the study; data types and sources are discussed. Image processing, classification of the images into different themes, mode of questionnaire administration and method of data analysis are also discussed.

3.2. THE STUDY AREA

3.2.1. Location and size

Southern part of Kaduna Metropolis is located between Latitudes 10˚ 23'30''N to10˚ 29' 30''N and Longitudes 7˚ 21'45''E to 7˚ 31'30''E (Fig 3.1). The area has a total land mass of 319.16km² and about 144 kilometres from Abuja, the new Federal Capital and some 846 kilometres from Lagos, the defunct Federal Capital of Nigeria. The area is bounded by River Kaduna to the north and extends southwards to cover all the settlements south of the River (Oyedele, 1977). fig. 3.1. and 3.2. There are twenty two (22) settlements or localities namely; Barnawa, Kakuri, Sabon-Tasha, Marraban-Rido, Gonin-Gora, Unguwan Musa, Unguwan Romi, Kakau, Kamazo, Makera, Television, Unguwan Yelwa, Narayi, NNPC, Unguwan Sunday, Unguwan Sale, Kudansa, Nasarawa, etc. in the study area.

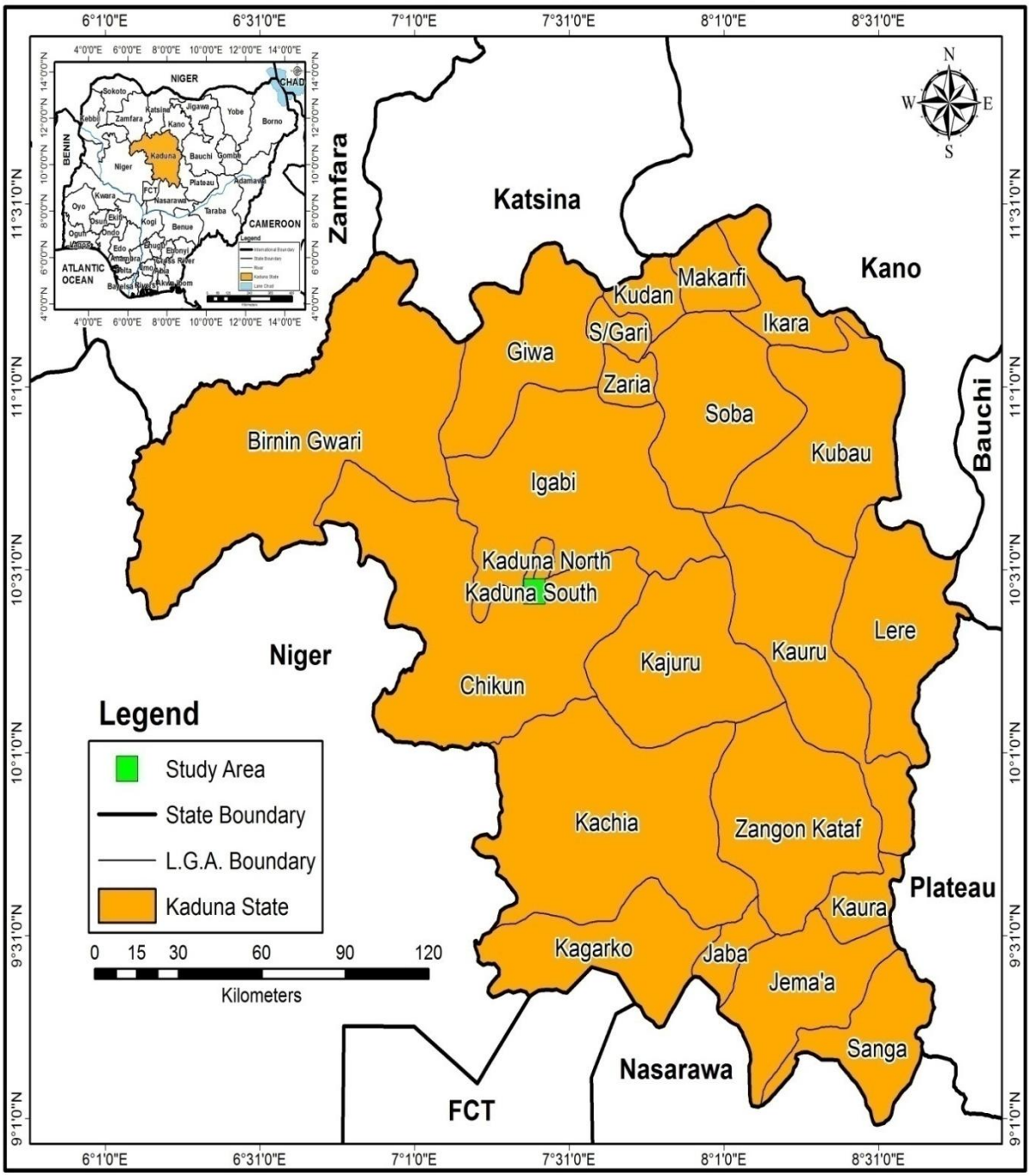

Figure 3.1: Kaduna state showing the study area.

Source: Modified from the Administrative Map of Kaduna State.

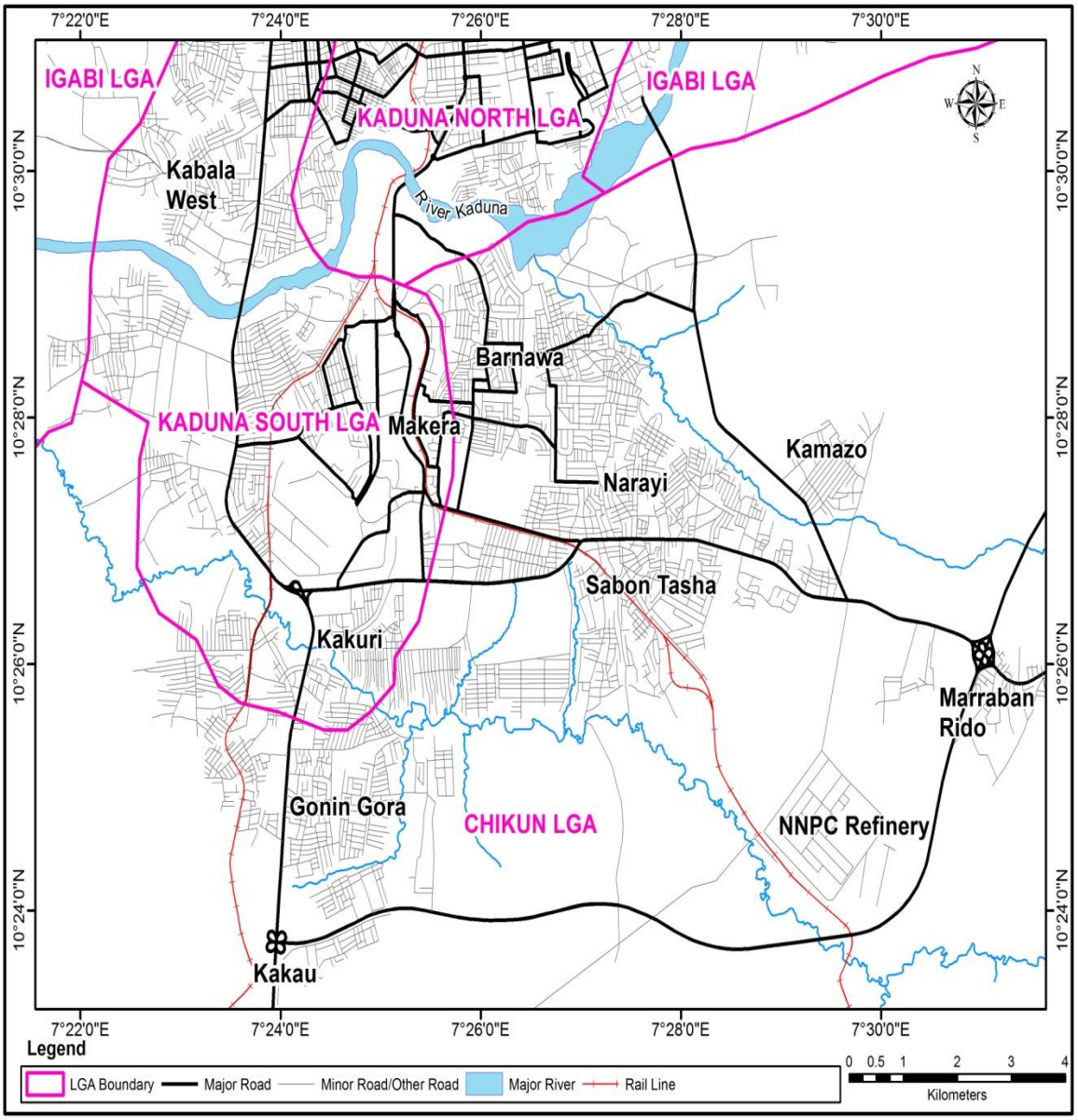

Figure 3.2: Southern part of Kaduna Metropolis.

Source: Modified from the Administrative Map of Kaduna State.

3.2.2. Weather and Climate

Southern part of Kaduna Metropolis lies on an enclosed gentle rolling within the undulating high plains of northern Nigeria (Musa, 1993). It has a general pattern of the West African interior/continental climate with marked dry and wet seasons. The dry season lasts from November to March. The mean annual rainfall is about 1525mm and the length of the rainy season period is about 200 days. The mean monthly temperature reaches 28ºC in March and drops to 23.3ºC in December (Abaje and Giwa, 2008). Humidity is constantly high (above 60%) at mid-day and close to 100% at night during the rainy season (Ati, 1998 in Ndabula, 2006).

3.2.3. Geology and Relief

The geological composition of Southern part of Kaduna Metropolis consist of biotite younger granites and older granite, undifferented gneiss with migmatite and granite of the basement complex. The geology has experienced deep chemical weathering followed by fluvial erosion, which in turn is influenced by the bioclimatic nature of the environment. Also, an isolated residual hill of different origins, sizes and shapes interrupts the infinite horizontality of the landscape (Atere,1991)**.**

3.2.4. Vegetation, Soil and drainage

The vegetation is shrub savannah interspersed with orchard bush, which represents a degradation of the natural vegetation. In its natural state, this zone is supposed to have

slightly thick woodland and tall grasses. However, the vegetation has been modified over the centuries by intense cultivation, grazing and burning. The drainage network is dominated by River Kaduna flowing southwest to join the River Niger. The River possesses good agricultural soils. Southern part of Kaduna metropolis soils is a typical of Zaria soils which falls within the ferruginous tropical soils. The soils are deeply weathered with fine particles up to 50m deep (Jackson, 1958). A profile of the soil section indicates and accumulation of clay between a depth of 36cm and 119cm (Jaieyeoba, 1986). The main crops grown are maize, guinea corn, millet, tomatoes, onions, pepper vegetables etc.

3.2.5. Economic activity

The land of the study area is mostly used for agricultural purposes for the production of food. The pre-occupation of the indigenes were predominantly farmers who produce food in large quantities due to massive agricultural lands. Agricultural activities are common in the rainy season and involve mostly manual cultivation of the primary food and cash crops such as maize, yams, cassava, millet, rice etc. A little percentage of the people also practice Dry Irrigation Farming for the production of tomatoes, Vegetables and other perishable goods with Kaduna River being the major source of water for the irrigation farming.

The activities in southern part of Kaduna metropolis also reflect the commercial services, administrative, industrial, transport and professional needs of the area, Kaduna metropolis and the entire Country. Here, all modern infrastructural facilities are present

being part of Kaduna urban area. There is electric power supply, pipe borne water, good roads, several banks, telephone services etc.

Textiles industries have found Southern part of Kaduna metropolis very ideal and so there are at least seven textile mills which employed quite a large labour force. Other industries include breweries, bottling companies, flour mills to mention just a few. This concentration of industries attracted many, especially youth to take part in the economic development of the area **(**Atere, 1991).

3.2.6. Population

Southern part of Kaduna metropolis is a multi-ethnic society. Available evidence shows that the area is inhabited by many ethnic groups. The inhabitants are of mix grill with southern Kaduna people dominating the population. These include Kurama, Kagoro, Marwa, Ninzom, Kadara, Jaba, Bajju, Kataf, Kaninkon, Gwagyi (Gwari), Ikulu,Mada, Gure etc. Others are Hausa, Fulani, Igbo, Idoma, Tiv, Berom Igala and a host of other ethnic nationalities. All of them settled as a result of the diversity of functional economic activities such as administrative, industrial and extensive trading activities.

The population of southern part of Kaduna metropolis stood at 299,451 and is expected to reach 597,280 by the year 2014 as projected by the researcher. The population was computed from the 1991 National Population Figures of the localities that constitutes the study area. Table 3.1 shows the population of localities in the three major residential neighbourhoods in southern part of Kaduna Metropolis according to 1991 Census figures.

Table 3.1: The population of localities in southern part of Kaduna Metropolis

RESIDENTIAL NEIGHBOUHOOD	LOCALITY	1991 CENSUS FIGURES	2014 PROJECTED POPULATION
Sabon-Tasha	Sabon-Tasha	27,251	54,354
	Ung-Television	28,344	56,535
	Kudansa	334	666
	Ung-Romi	8,182	16,320
	Romin Fulani	559	1,115
	Gonin Gora	3,806	7,591
	NNPC Staff Qtrs	2,656	5,298
	Ung-Sunday	6,838	13,639
	Ung-Yelwa	24,385	48,638
	Maraba	828	1,652
	Rido-Hausawa	918	1,831
	Hayin-Rido	606	1,209
	Rido-Ung-Ali	596	1,189
	Maraban-Rido	559	1,115
	Maraban rido gwari	441	880
	Ung-Sale	1,099	2,192
	Kakau	622	1,241
	Ung-Musa	576	1,149
	Kamazo/Mahuta	447	892
Kakuri/Makera	Kakuri / Makera	77,374	154,329
	Nasarawa/ Kudanda	56,674	113,041
Barnawa	Barnawa	32,684	65,191
	Narayi High Cost	23,674	47,220
TOTAL		299,451	597,280

Source: NPC, 1991

Since the breakdown of 2006 census figures of the localities were unavailable, the 2014 population figures of all the localities that fall within each of the three residential neighbourhood was projected from 1991 census figures based on the approved annual exponential population growth rate of 3% (NPC, 1991). The NPC recommended the use

of exponential method to project population in order to take care of the inadequacies arising from the census data. Therefore, the exponential method of population projection was used to obtain the 2014 projected population of all the localities within the three residential neighbourhoods.

3.3. RESEARCH METHODOLOGY

A reconnaissance survey of the study area was undertaken by the researcher to get familiar with the study area.

3.3.1. DATA TYPES AND SOURCES

The following data were used to achieve the aim and objectives of the study.

The data are:

Satellite imageries: The satellite imageries were used to generate land use and land cover maps of the study area, from 1990 to 2014; for easy visualization, identification and extraction of information. They include the following;

i. Landsat 4 Thematic Mapper (TM) with 30m spatial resolution of 27th November, 1990 was sourced from National Centre for Remote Sensing (NCRS), Jos.
ii. Landsat 7 Enhanced Thematic Mapper Plus (ETM +) at 30m spatial resolution of 24th October, 2001 was sourced from National Centre for Remote Sensing (NCRS), Jos.

iii. Landsat 8 Enhanced Thematic Mapper Plus (ETM +) at 30m spatial resolution of 23rd February, 2014 was sourced from National Centre for Remote Sensing (NCRS), Jos.

Topographical map: Topographic map at a scale of 1: 250,000 was use to delineate the study area and extract settlements information in the study area. It was sourced from Kaduna State Ministry of Lands and Surveys.

Field survey data: This data was used to obtain the bio-demographic and socio-economic information of the respondents (farmers) and was sourced through questionnaire administration.

Other data sources: Other data sources were sourced from relevant literature material, relevant textbooks, journals articles, dissertations, research papers and internet.

3.3.2. HARDWARE AND SOFTWARE

3.3.2.1. Hardware

i. High speed memory digital electronic computer hardware Hewlett Packard (HP) 2000 Was used to carry out the entire work.
ii. Garmin Map pro 76 Global Positioning System (GPS) was used to show approximate location of the salient points for easy identification on the imagery.

3.3.2.2. Software

i. Erdas Imagine 9.2 was used for the generation of land use/land cover maps and classification of the satellite data. It was selected for use because of its

functionality, availability and efficiency.

ii. Arc GIS 10.1 was used in the overlay analysis.

3.3.3. Data processing

Satellite data comes in bands and covers a large area of land, though ortho-rectify, certain pre-processing operation is needful. However, the two pre-processing operation that were carried on the imageries before classification are Image Geo-referencing and Image Sub-setting. Galster (2001), argued that Remotely Sensed data were more widely used for analysis of pattern and processes rather than determining causes and implications.

3.3.3.1. Image Geo-referencing

The Image Geo-referencing involves registering image data to the real world was achieved by importing the satellite images into ERDAS Imagine 9.2 environment. The satellite data was rectified to a common projection (Universal Traverse Mercator (UTM) zone 32) in order to make its coordinates conform to the real world.

However, Image Resampling was not carried out on the imageries because the satellite images had the same resolution of 30m each and therefore, compatible with each other for overlay operation. Both are ortho-rectified with the same geo-referenced parameters.

3.3.3.2. Image Sub-setting

ERDAS Imagine 9.2 was used for sub-setting the full satellite images of southern part of Kaduna metropolis from the full scene of the imageries. It was in order to extract the area of interest since satellite images comes in bands and cover a large area of land. Bands 1, 2, 3, 4 and 5 and 7 were layer composite for the purpose of landuse and land cover classification. The scene was sub-setted by selecting or go to inquire cursor and type the coordinates of the area of interest and then click enter, the white cross then falls in the middle of the area of interest.

Finally, the images were displayed in a False Colour Composite (FCC) for a better visualization and identification of the Land Use/Land Cover (LULC) categories using ERDAS Imagine 9.2 software.

3.3.4. Image Classification

Mather (1999) considered classification to be the process of pattern recognition associated with each pixel position in an image. Lark (1995) identified two major proceedures for image classification; unsupervised and supervised classification. According to Lark (1995), unsupervised classification proceedure involved the computer automatically groups features into classes based on the demand of the user. While in the supervised classification technique, the user controls the process.

In this study however, for the purpose of pattern recognition and classification of the images into various classes, a supervised classification technique was performed using

maximum likelihood algorithm because of its high level accuracy and reliability in handling spatial data (Drury, 1990). Polygons were identified by attaching independent labels on the centroid of each polygon. The polygons were thereafter labelled as training sites. Training is the process of defining the criteria by which patterns in data are recognized (Hord, 1982). The training sample was collected based on the ground truth data; and the pectral values of the training samples were then selected and coded with class names and then merged to give an average pattern for the category.

The development of a classification scheme was based on the prior knowledge of the study area, reconnaissance survey and additional information from previous researches. The Classification covered 5 LULC classes. The classification scheme rather formed a broad classification as shown in table 3.2

TABLE 3.2: Classification Scheme

CODE	LAND USE/LAND COVER CATEGORIES	DESCRIPTION
1	Build-up land	Land used for settlements and building of urban infrastructures such as roads, schools, railways etc.
2	Agricultural land	Land used as cropland, agricultural plantation such as farmlands and orchards etc.
3	Vegetated land	Lands covered natural vegetation that is predominantly grasses, shrubs and grass-like plants and natural forest
4	Water body	Streams, Rivers, dams and ponds
5	Bare land	Exposed soils, land devoid of vegetal cover

Source: Modified from Anderson, Hardy, Roach, and Witmer (1967)

3.3.4.1. Ground Truthing and Accuracy Assessment

Ground control coordinates obtained using a Global Positioning System (GPS) from locations in relation to the classes under study were plotted on the images to verify the accuracy of the classified training sites as regards to their spectral signature.

An accuracy assessment matrix was generated using the error matrix and Kappa Coefficient. The Kappa Coefficient according to Congalton (1991) expresses the proportional reduction in error generated by a classified process compared with the error of a completely random classification.

For the purpose of this study, Classification accuracy was assessed by picking 25 ground control points based on the recommendations of Van Genderen & Lock (1977), who stated that a minimum sample size of 20 to 30 observations (reference pixels) per class are required for an acceptable classification accuracy assessment. Therefore, the 25 ground control points from each land use are converted to raster in ArcGIS. A signature tool was used to combine the cells with those of the classified image. This resulted in a Confusion Matrix table 3.3 which was exported to excel to calculate Kappa.

Table 3.3. Confusion Matrix showing the accuracy of classification

Landuse	Built-up land	Agriculture land	Vegetated land	Water body	Bare surface	Total	User's Accuracy
Built-up land	**17**	2	3	2	1	25	68%
Agriculture land	2	**18**	2	1	2	25	72%
Vegetated land	4	2	**15**	2	2	25	60%
Water body	2	3	1	**16**	3	25	64%
Bare land	1	1	2	3	**14**	25	56%
Total	26	26	23	24	22	**125**	
Producer's Accuracy	65%	69%	65%	67%	64%		Total 80

Source: Author's Analysis, 2014

As shown in table 3.3, built-up areas had 17 of the 25 control points matching the points on the classified images and therefore, had a User's accuracy of 68% and Producer's accuracy of 65%. Agricultural land had the highest level of accuracy with 18 of the 25 control points matching the points on the classified images and therefore had a User's accuracy of 72% and also 69% Producer's accuracy. Vegetated land had a total of 15 control points of the 25 matching the points on the classified images, it had a User's accuracy of 60% and Producer's accuracy of 65%. Water body had a total of 16 control points of the 25 matching the points on the classified image; it had a User's accuracy of 64% and Producer's accuracy of 67%. While bare surface had a total of 14 control points of the 25 control points matching the points on the classified image; it had a User's accuracy of 56% and Producer's accuracy of 64%. Therefore, table 4.4 reveals that 80 out of the 125 total control points matched their actual points on the classified image.

Total Accuracy = [(17 + 18 +15 + 16 + 14)/100] *100 = 80%

The calculation for the overall accuracy is obtained using *Kappa* statistic (Congalton, 1991).

$$K = \frac{p_o - p_e}{1 - p_e}$$

Where K = Kappa

Po = Observed Accuracy

Pe = Expected Accuracy

Observed Accuracy = 0.71

Expected Accuracy = 0.5

$$K = \frac{p_o - p_e}{1 - p_e} = 0.71\text{-}0.5/1\text{-}0.5 = 0.41$$

A kappa accuracy of 0.41 is said to be fair or good according to Congalton (1991).

3.3.5. Questionnaire administration

Socio-demographic data of the farmers such as age, sex, gender and marital status as well as socio-economic data such as duration of stay in the study area, type of occupation, size of farmlands, yield of farm output etc was obtained through the administration of questionnaire to the farmers within the study area. The target population were indigenous farmers because they are the ones that are directly affected by urban expansion being a driver of landuse and land cover change and are in the best position to provide needed information on how urban expansion affects their farming livelihood. The questionnaire were Administered to the farmers to their door posts with the assistance of the village heads popularly known as ‘’Sarki’’ or ‘’Maiunguwas’’ in hausa who are familiar with the residential houses of the farmers

3.3.5.1. Sampling technique and Sampling size

The sampling frame for the study was Southern part of Kaduna Metropolis and comprised of parts of Kaduna south, Chukun, and Igabi Local Government Areas. Hence, all the localities under Southern part of Kaduna Metropolis were used to form the

sampling frame. There were 23 localities namely; Barnawa, Kakuri, Sabon-Tasha, Marraban-Rido, Gonin-Gora, Unguwan Musa, Unguwan Romi, Kakau, Kamazo, Kudansa, Makera, Television, Unguwan Yelwa, Narayi, NNPC, Unguwan Sunday, Unguwan Sale, and Nasarawa. The neighbourhoods rather sub-divided into three major residential neighbourhoods namely; Sabon-Tasha, Barnawa and Kakuri for easy administration and collation of questionnaire. Therefore, all the localities in the entire three residential neighbourhoods constituted the sampling frame.

According to National Population Census (NPC,1991), the total estimated population of the study area stood at 299,451 comprising 158,448 males and 140,098 females. The population of the study area was expected to reach 597,280 by the year 2014 as projected by the researcher from 1991 National Population figures at 3% growth rate. The 1991 census figures were used due to non availability of 2006 breakdown of census figures based on localities. Table 3.4 shows the population of the three major residential neighbourhoods in southern part of Kaduna Metropolis according to 1991 census figures, as projected by the researcher.

Table 3.4: Neighbourhood Population of southern part of Kaduna Metropolis

RESIDENTIAL NEIGHBOURHOOD	1991 CENSUS POPULATION	2014 PROJECTED POPULATION
Sabon-Tasha	109,048	217,506
Kakuri	134,049	267,372
Barnawa	56,358	112,412
TOTALS	299,451	597,280

Source: Author's analysis

The breakdown of the 2014 projected population by sampled localities is presented in table 3.5.

Table 3.5: Sample size

Residential Neighborhood	Locality	1991 Census	2014 Projected Population	Sample Size Per Residential Neighbourhood
Sabon-Tasha	Sabon-Tasha	27,251	54,354	217,502
	Ung-Television	28,344	56,535	
	Kudansa	334	666	
	Ung-Romi	8,182	16,320	
	Romin Fulani	559	1,115	
	Gonin Gora	3,806	7,591	
	NNPC Staff Qtrs	2,656	5,298	
	Ung-Sunday	6,838	13,639	
	Ung-Yelwa	24,385	48,638	
	Maraba	828	1,652	
	Rido-Hausawa	918	1,831	
	Hayin-Rido	606	1,209	
	Rido-Ung-Ali	596	1,189	
	Maraban-Rido	559	1,115	
	Maraban rido gwari	441	880	
	Ung-Sale	1,099	2,192	
	Kakau	622	1,241	
	Ung-Musa	576	1,149	
	Kamazo/Mahuta	447	892	
Kakuri/Makera	Kakuri / Makera	77,374	154,329	267,368
	Nasarawa/ Kudanda	56,674	113,041	
Barnawa	Barnawa	32,684	65,191	112,410
	Narayi High Cost	23,674	47,220	
Total		299,451	597,280	597,280

Source: Modified from NPC, 1991

The sampling size of the questionnaire administered was derived from the formula of Yamane (1976) expressed as follows:

Sampling size = $N/ [\{1 + N(e)^2\}]$

Where N = total population of selected localities under study

e = error margin = 0.05 or 5%

Therefore, sample size = 597280 / [(1 + 597280 X $(0.05)^2$] = 400

The number of questionnaire that was administered was proportionate to the population of each locality.

Thus, proportion = n/N x 400

Where n = population of the sample locality

N = total population of the sample localities under same residential neighbourhood

Therefore, the total number of questionnaire administered to the farmers was four hundred (400) and the proportion per each locality is shown in table 3.6.

Table 3.6: Proportion of questionnaire administered in each locality

Residential Neighbourhood	2014 Projected Population Of Residential Neighbourhood	Sample Localities Under Same Residential Neighbourhood	2014 Projected Sample Population Of Localities	Proportion of questionnaire per sample locality
Sabon-Tasha	217,504	Sabon-Tasha	54,354	36
		Ung-Television	56,535	39
		Kudansa	666	1
		Ung-Romi	16,320	11
		Romin Fulani	1,115	1
		Gonin Gora	7,591	5
		NNPC Staff Qtrs	5,298	4
		Ung-Sunday	13,639	9
		Ung-Yelwa	48,638	33
		Maraba	1,652	1
		Rido-Hausawa	1,831	1
		Hayin-Rido	1,209	1
		Rido-Ung-Ali	1,189	1
		Maraban-Rido	1,115	1
		Maraban rido gwari	880	1
		Ung-Sale	2,192	2
		Kakau	1,241	1
		Ung-Musa	1,149	1
		Kamazo/Mahuta	892	1
Kakuri/Makera	267,370	Kakuri / Makera	154,329	101
		Nasarawa/ Kudanda	113,041	75
Barnawa	112,411	Barnawa	65,191	43
		Narayi High Cost	47,220	31
Totals	597,280		597,280	400

Source: Author's analysis 2014

3.3.6. Data analysis

Landuse and land cover maps of the study area was generated from which a histogram (Image statistics) was constructed and the extent of the landuses and land cover distribution was determined for the three time periods. The magnitude of the landuse and land cover distribution was further obtained by subtracting the area coverage of the

landuses in the generated land-use/land-cover maps of the former from the latter; that is, (Reference year – The base year). For example, the area in km² in 2001- the area in km² in 1991 etc. While, the annual rate of change of landuse and land cover was determined by dividing the magnitude by the number of years between periods multiply by 100%.

Mathematically;

Reference year – Base year = Growth in hectares.

Where:

Reference year = the latter study year or period eg. 2014.

Base year = the former study year or period eg. 1990.

Rate of change = {(Growth in hectares/No of years between periods) X 100%)}

A clipping tool in ArcGIS 10.1 was used to determine the extent to which urban landuse encroached into other landuses. While, annual loss was obtained by dividing the loss between periods by the number of years between each period.

Perception of the farmers on the implications of landuse and land cover changes was assessed through the administration of questionnaire in order to determine whether urban expansion as a major driver of landuse and land cover change has led to the disappearance of agricultural landuse. Simple statistics such as tables, bar charts and pie charts was used to present the result.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter deals with presentation and discussion of results. The results are presented in tables 4.1 to 4.15 and figures 4.1 to 4.15. The presentation and analysis of the data was carried out under the following sub-themes; Extent of landuse and land cover distribution, magnitude and rate of change in landuse and land cover distribution, extent of urban landuse encroachment on other landuses and the implications of urban expansion to the farmers.

4.2. LAND-USE AND LAND-COVER DISTRIBUTION

The land use/land cover classes in Southern Part of Kaduna Metropolis (SPKM) in 1990, 2001 and 2014 is shown in table 4.1 and figures 4.1, 4.2, and 4.3

Table 4.1 Land use/Land cover distribution in 1990, 2001 and 2014

Year	1990		2001		2014	
Land use	km²	%	km²	%	km²	%
Built-up land	40.56	12.71	61.71	19.34	116.12	36.38
Agricultural Land	213.79	66.99	201.18	63.03	158.98	49.81
Vegetated land	28.07	8.79	22.46	7.04	14.56	4.56
Bare Surface	33.50	10.50	31.17	9.77	27.20	8.52
Water Body	3.25	1.02	2.64	0.83	2.30	0.72
Total	319.16	100.00	319.16	100.00	319.16	100.00

Source: Author's analysis 2014

Table 4.1 shows that Built-up areas is the second dominant landuse in 1990 as it occupied 40.56km² (12.71%) of the total land area. In 2001, it occupied an area of 61.71 km² (19.34%) while in 2014, it covers an area of 116.12 km² (36.38%). However, Agricultural Landuse has the dominant coverage of 213.79 km² (66.99%) in 1990. In 2001, it occupies an area of 201.18 km² (63.03%) and in 2014, it occupies an area of 158.98 km² representing 49.81%. Vegetated landuse occupied a total land area of 28.07 km² (8.79%) in 1990, while in 2001, it covers an area of 22.46 km² (7.04%) and in 2014, it occupies an area of 14.56km² (4.56%). Bare Surfaces which resurfaces

in Sabon-Tasha, Maraban-Rido and some other areas within the study areas, occupied an observable land area of 33.50 km² (10.50%) in 1990. In 2001, it covers a total land area of 31.17 km² (9.77%) and it occupied a total land area of 27.20 km² representing 8.52% in 2014. On the other hand, the study revealed that Water Body had the lowest proportion of land coverage (3.25 km²) representing 1.02% in 1990. In 2001, it occupies an area of 2.64 km² (0.83%) and covers an area of 2.30 km² (0.72%) in 2014 (figures 4.1, 4.2, 4.3).

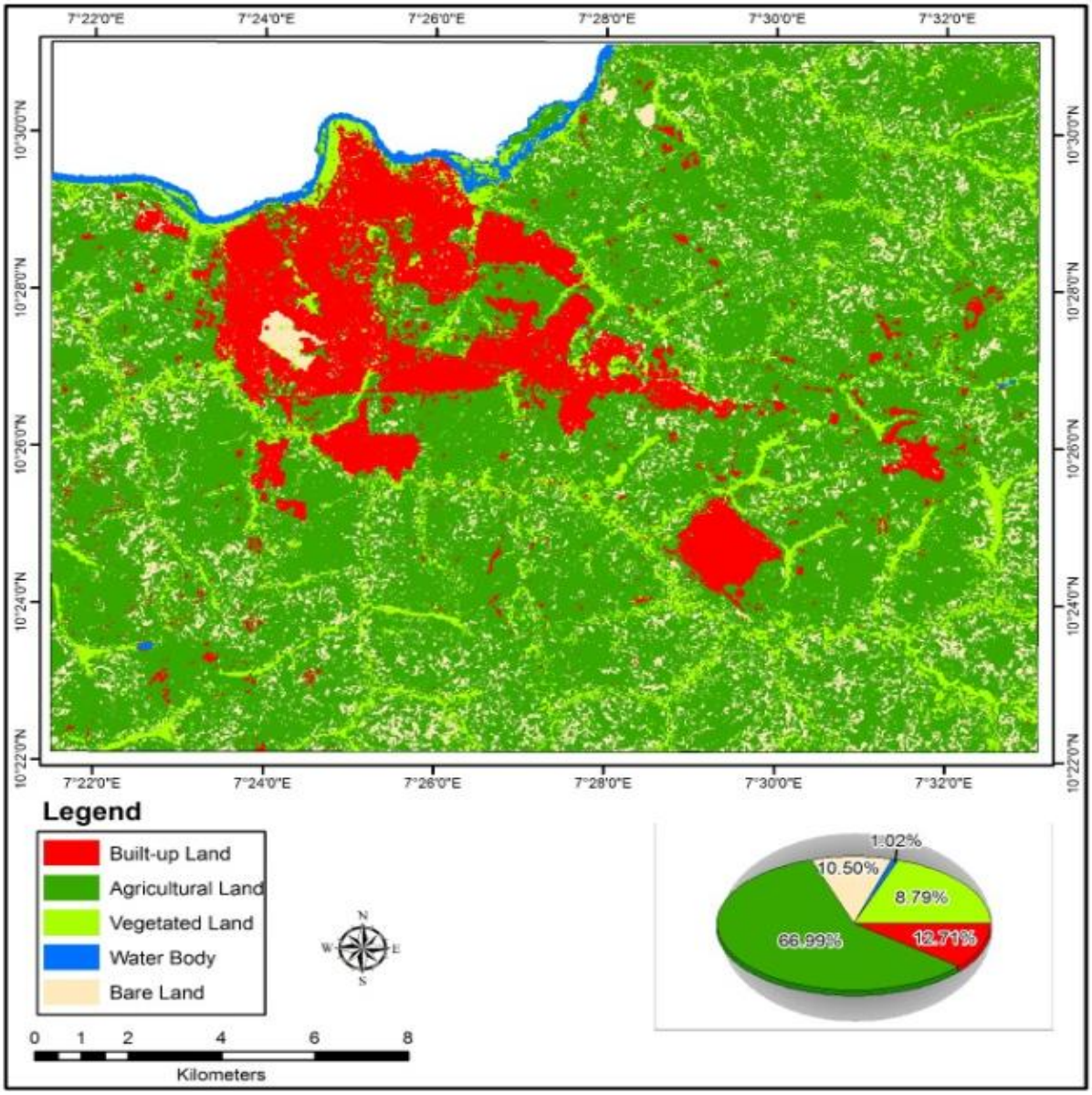

Figure 4.1; Land use Land cover distribution of Southern part of Kaduna Metropolis in 1990

Source: Author's Analysis, 2014

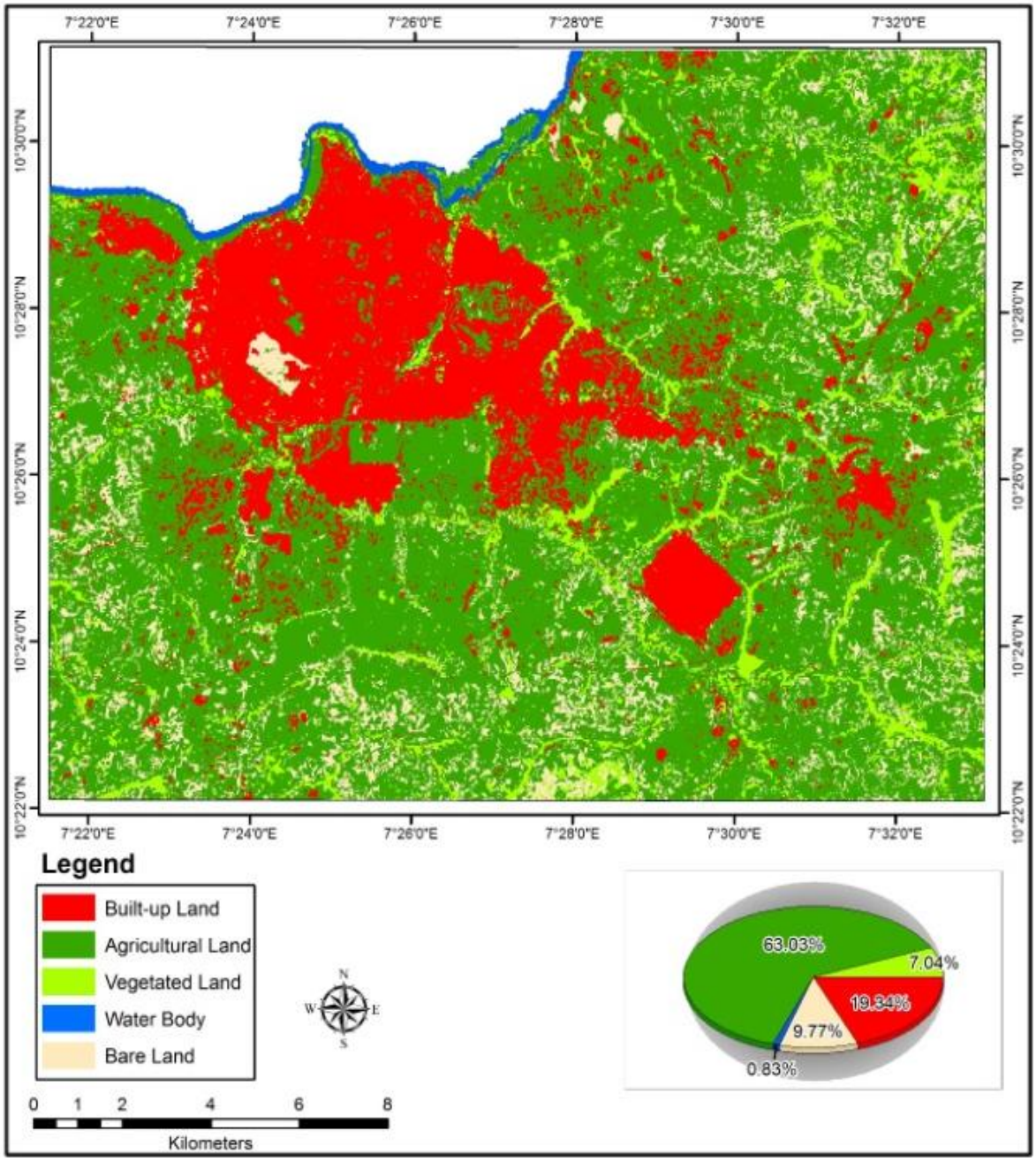

Figure 4.2; Land use Land cover distribution of Southern part of Kaduna Metropolis in 2001

Source: Author's Analysis, 2014

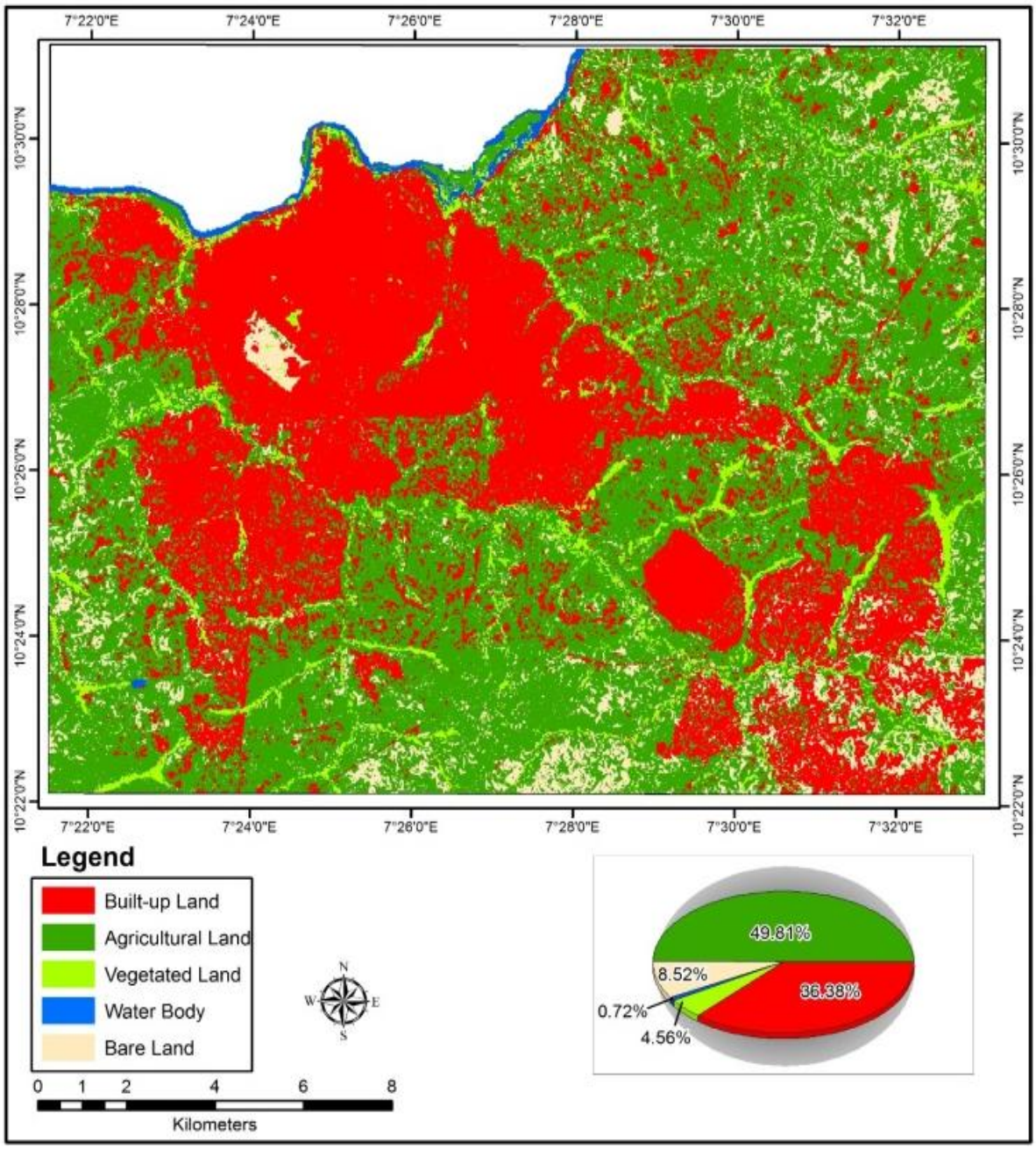

Figure 4.3; Land use Land cover distribution of Southern part of Kaduna Metropolis 2014.

Source: Author's Analysis, 2014

4.3 MAGNITUDE AND RATE OF CHANGE IN LANDUSE AND LAND COVER

The magnitude and annual rate of change in landuse and land cover distribution between periods of 1990 and 2001 and between 2001 and 2014 are presented in tables 4.2, 4.3, 4.4, 4.5, 4.6 and figures 4.4, 4.5, 4.6, 4.7, 4.8.

Table 4.2; Magnitude and annual rate of change in urban landuse between 1990 and 2001 and between 2001 and 2014.

Period	Year	Urban landuse in (km²)	Increase		Arithmetic Mean (Rate of Increase)	
			km²	%	km²/Year	%/Year
1990-2001 (11 Years)	1990	40.56	21.15	52.15	1.92	4.74
	2001	61.71				
2001-2014 (13 Years)	2001	61.71	54.41	88.17	4.19	6.78
	2014	116.12				
1990-2014 (24 Years)	1990	40.56	75.56	186.29	3.15	7.76
	2014	116.12				

Source: Author's Analysis, 2015

The result in table 4.2 and figure 4.4 shows that the increase in urban landuse between 2001 and 2014 is more than double (54.41km²) compared with the urban land increase between 1990 and 2001 (21.15 km²). Consequently, the period between 2001 and 2014 shows an annual increase rate of 6.78%. This increase is almost double compared to 4.74% annual increase rate between 1990 and 2001. This increase, however, is substantial compared to the findings of Ishaya, Ifatimehin and Okafor (2008), whose result shows an overall increased of 1846.46ha from 1990 to 2000. This increase could be attributed to rapid urban expansion that is taking place in the area due to rapid socio-economic activities as a result of population increased. This increased in urban landuse mostly took

place between 2001 and 2014, a period which coincided with a period Kaduna metropolis witnessed most of its civic and religious crisis.

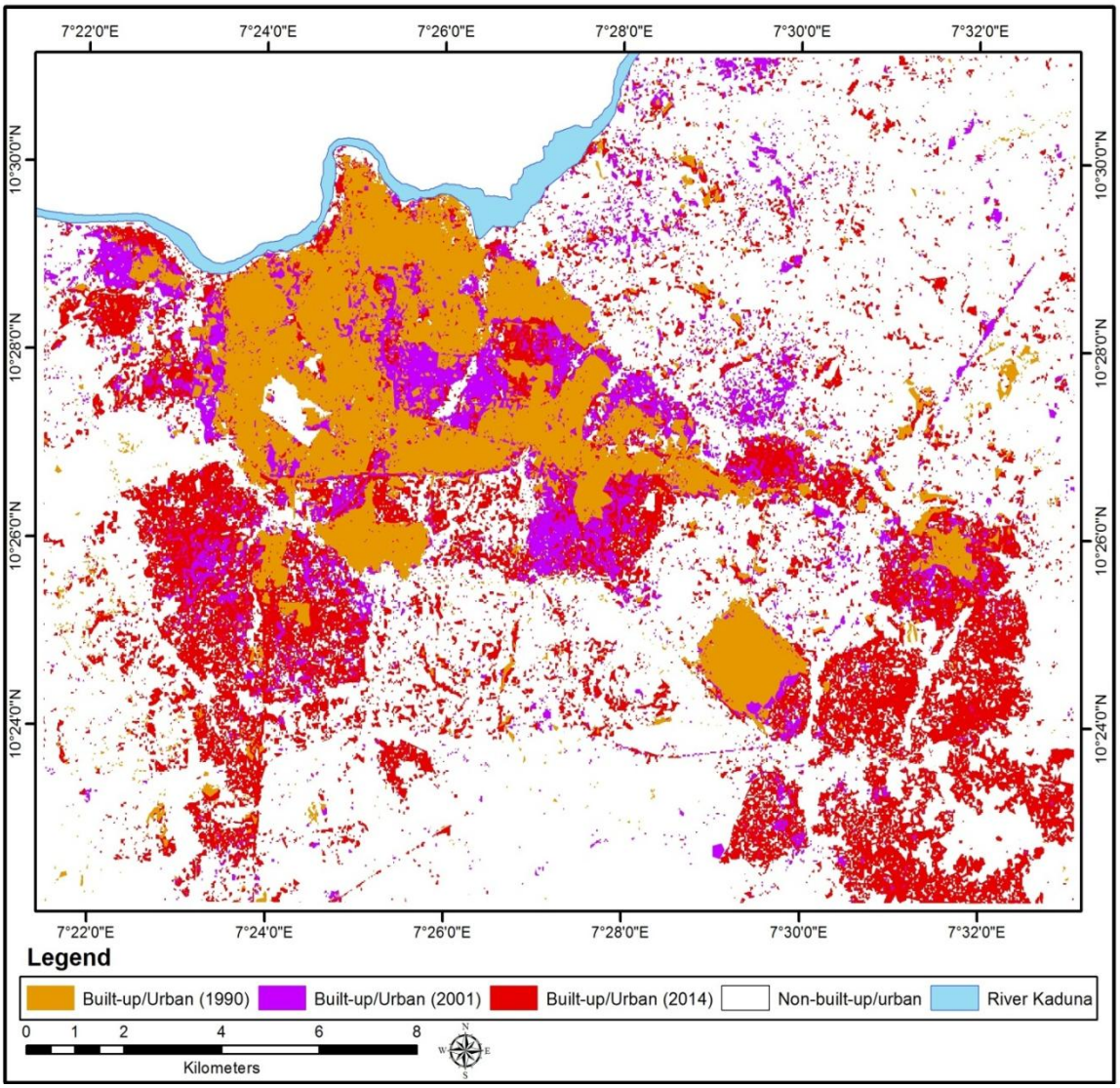

Figure 4.4: An overlay analysis showing the spatial changes (growth) of built-up areas in 1990, 2001 and 2014.

Source: Author's Analysis, 2014

Table 4.3; Magnitude and annual rate of change in agricultural landuse

Period	Year	Agricultural Landuse (km²)	Decrease		Arithmetic Mean (Rate of Increase)	
			(km²)	%	(km²)/Year	%/Year
1990-2001 (11 Years)	1990	213.79	-12.61	5.90	-1.15	0.54
	2001	201.18				
2001-2014 (13 Years)	2001	201.18	-42.20	20.98	-3.25	1.61
	2014	158.98				
1990-2014 (24 Years)	1990	213.79	-54.81	25.64	-2.28	1.07
	2014	158.98				

Source: Author's Analysis, 2015

Table 4.3 revealed that the period between 2001 and 2014 has the highest annual rate of loss (1.61%) compared to the annual loss of 0.54% between 1990 and 2014. This annual rate of loss between 2001 and 2014 is rather high and by implication, accounts for most of the decrease in agricultural land between the periods. The drop or decreased could be linked to an increased in urban landuse which increases simultaneously and displaces the agricultural land in the area (figure 4.5). Most of the lost also occurred between 2001 and 2014. i.e during the civil and religious disturbances in Kaduna metropolis.

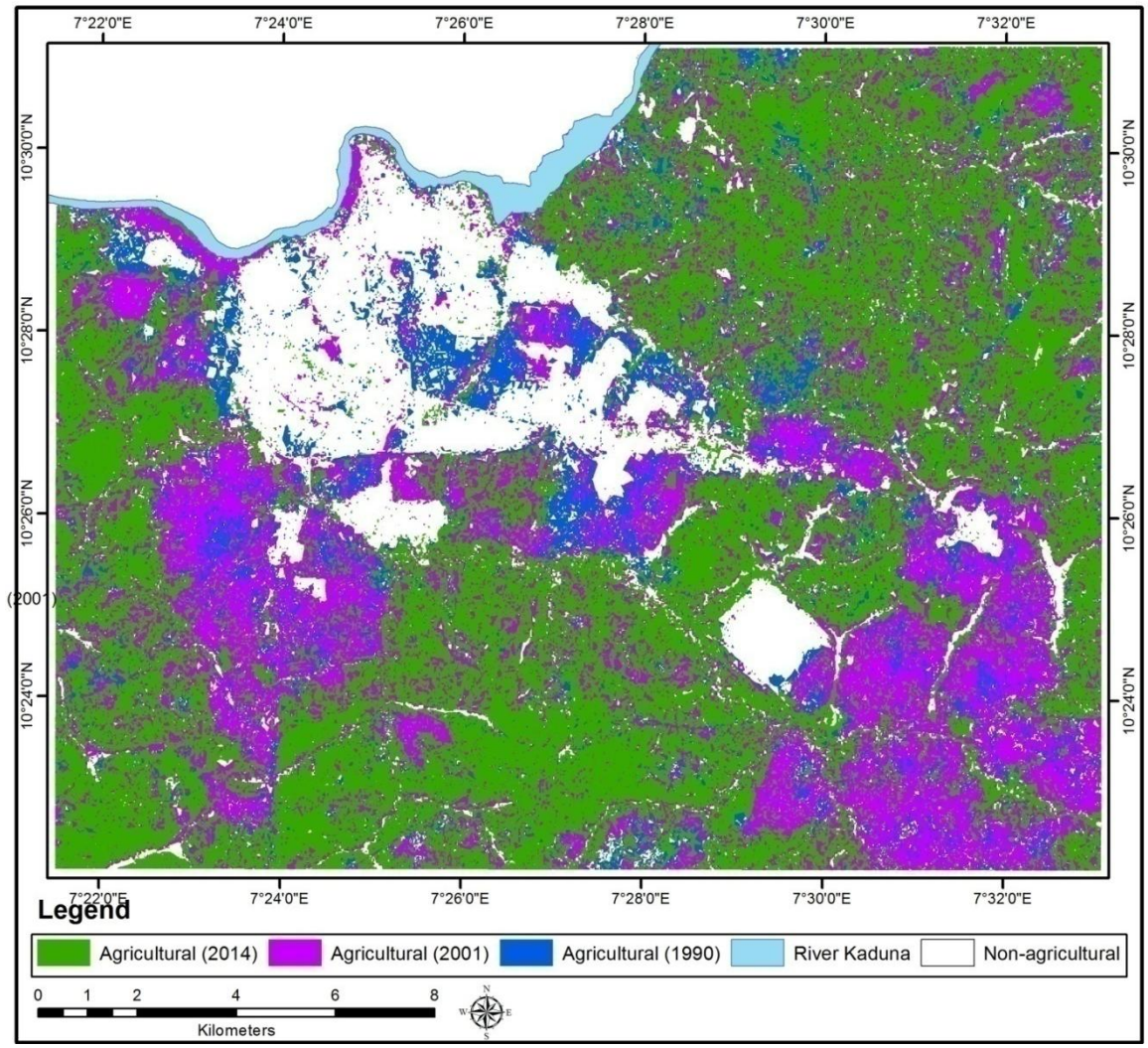

Figure 4.5: An overlay analysis showing the spatial changes (decrease) of agricultural land area in 1990, 2001 and 2014

Source: Author's Analysis, 2014

Table 4.4; Magnitude and annual rate of change in vegetation landuse

Period	Year	Vegetation Landuse (km²)	Decrease		Arithmetic Mean (Rate of Increase)	
			(km²)	%	(km²)/Year	%/Year
1990-2001 (11 Years)	1990	28.07	-5.61	19.99	-0.51	1.82
	2001	22.46				
2001-2014 (13 Years)	2001	22.46	-7.90	35.17	-0.61	2.72
	2014	14.56				
1990-2014 (24 Years)	1990	28.07	-13.51	48.13	-0.56	2.01
	2014	14.56				

Source: Author's Analysis, 2015

The result from table 4.4 revealed that the period between 2001 and 2014 has the highest annual rate of loss of vegetation landuse 7.90 km² representing 2.72% compared to the annual loss of 5.61 km² (1.82%) between 1990 and 2014. This annual rate of loss between 2001 and 2014 indicates that vegetation landuse lost twice of its landuse between 2001 and 2014 compared to 1990 and 2001 loss. Vegetation landuse is evenly scattered within the study area and most of it has been tempered with by the anthropogenic activities of man during the 2001 and 2014 civil and religious disturbances (figure 4.6).

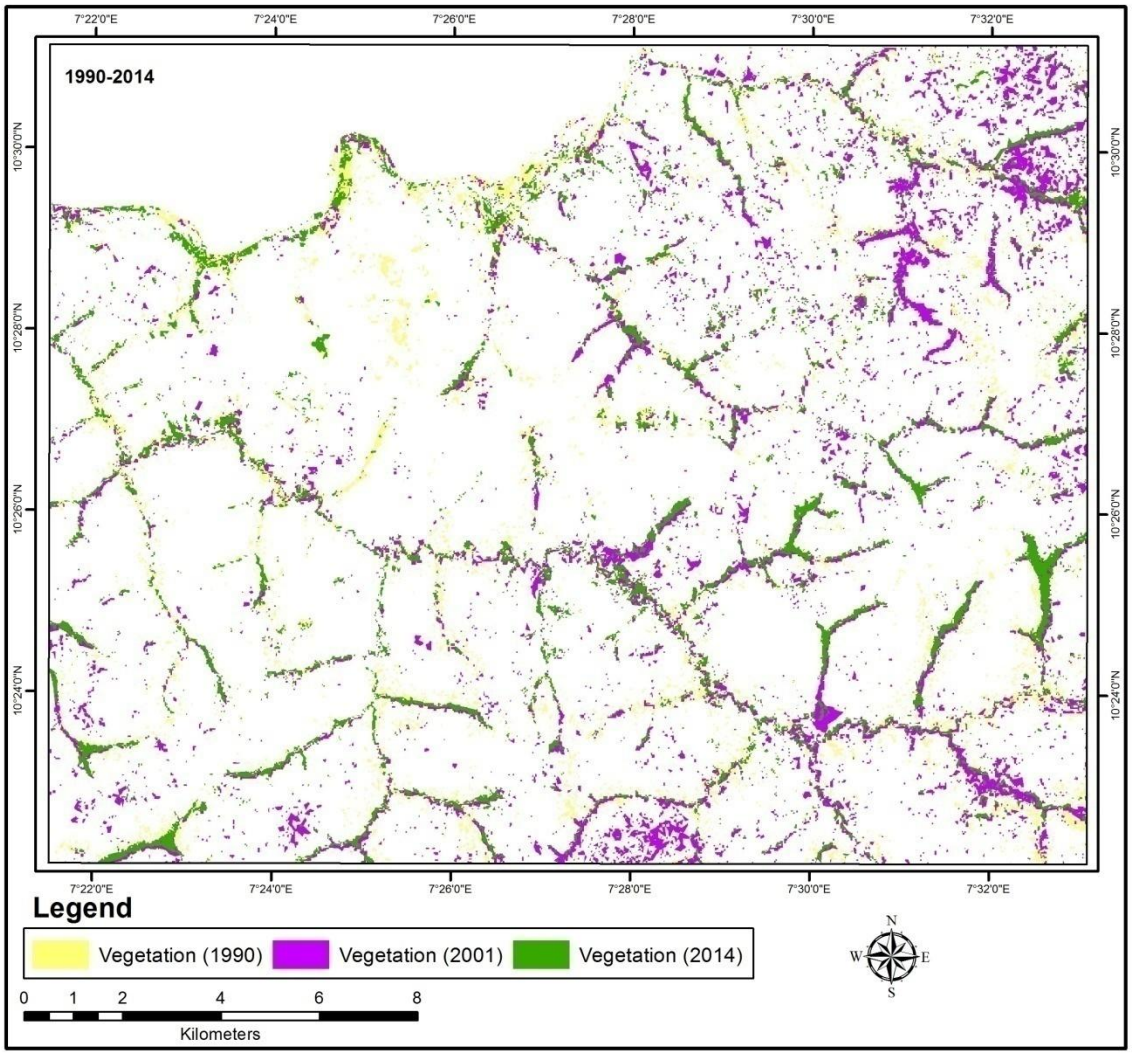

Figure 4.7: An overlay analysis showing the spatial changes (decrease) of vegetated landuse in 1990, 2001 and 2014

Source: Author's Analysis, 2014

Table 4.5; Magnitude and annual rate of change in bare land surfaces

Period	Year	Bare Landuse (km^2)	Decrease		Arithmetic Mean (Rate of Increase)	
			(km^2)	%	(km^2)/Year	%/Year
1990-2001 (11 Years)	1990	33.50	-2.33	6.96	-0.21	0.63
	2001	31.17				
2001-2014 (13 Years)	2001	31.17	-3.97	12.74	-0.31	0.98
	2014	27.20				
1990-2014 (24 Years)	1990	33.50	-6.30	18.81	-0.26	0.78
	2014	27.20				

Source: Author's Analysis, 2015

Bare land or surfaces are land that does not support agriculture but can be useful in the building of residential, infrastructure and can also be put into other landuses. However, table 4.5 shows that bare land or surfaces in the study area also diminished over the study periods. Most of the bare surfaces are seen between Romi and Command Secondary School. A trace of bare surfaces can be spotted in Unguwan Musa and Mahauta with other traces scattered all over the study area (figure 4.7).

Table 4.5 reveals that the periods between 2001 and 2014 recorded the highest loss ($3.97km^2$) in bare land surfaces amounting to 0.98% compared to 0.63% of the periods between 1990 and 2001. The loss could also be linked to an increased in urban landuse which also coincided to the crisis period of 2001 and 2014. This shows that bare surfaces could not have escaped the pressure exerted on them as most of it is also lost to urban landuse during the crisis period.

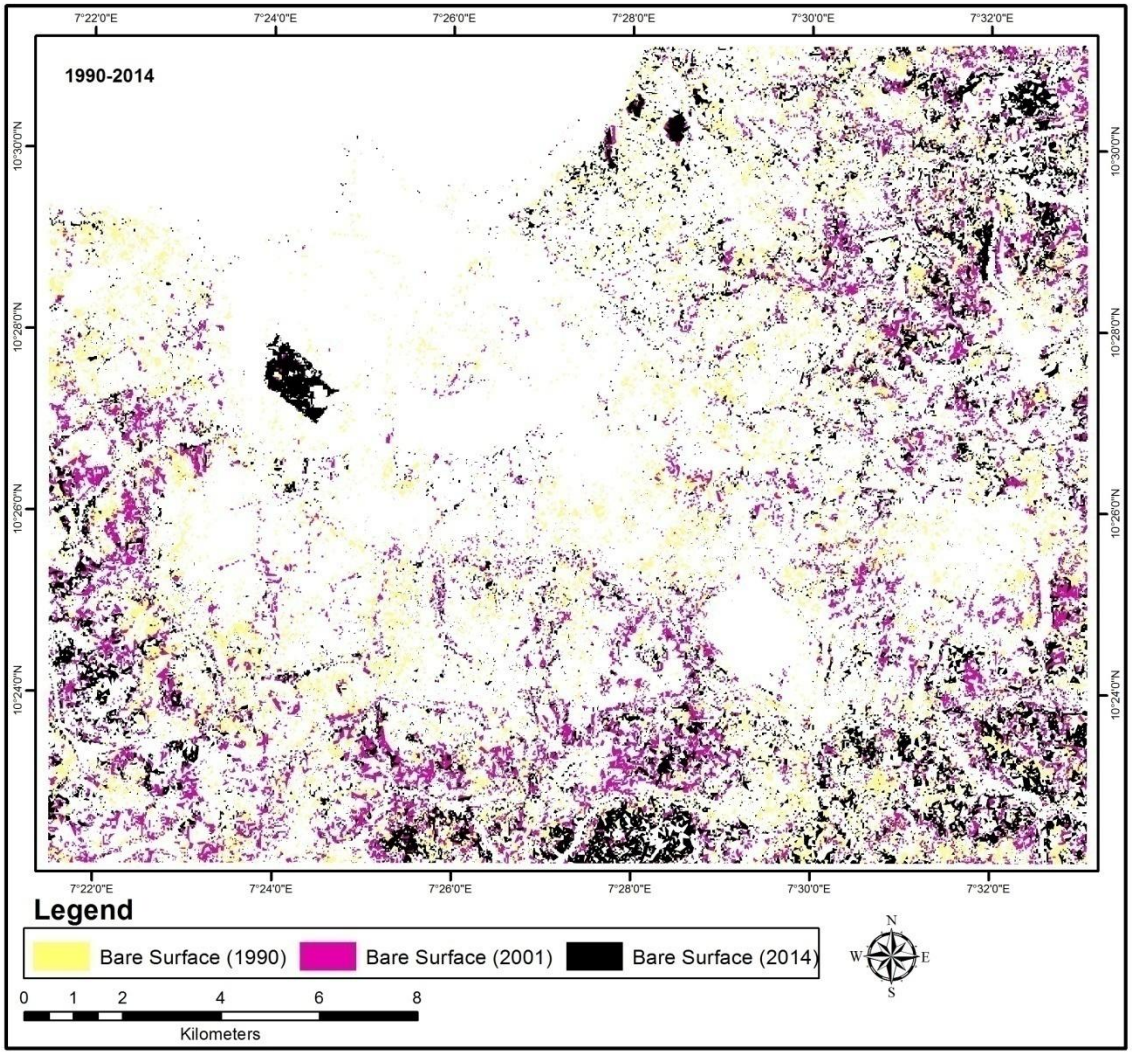

Figure 4.7: An overlay analysis showing the spatial changes (decrease) of bare surfaces in 1990, 2001 and 2014

Source: Author's Analysis, 2014

Table 4.6; Magnitude and annual rate of change in water surfaces

Period	Year	Water surfaces (km^2)	Decrease		Arithmetic Mean (Rate of decrease)	
			(km^2)	%	(km^2)/Year	%/Year
1990-2001 (11 Years)	1990	3.25	-0.61	18.77	-0.06	1.71
	2001	2.64				
2001-2014 (13 Years)	2001	2.64	-0.34	12.88	-0.03	1.13
	2014	2.30				
1990-2014 (24 Years)	1990	3.25	-0.95	29.23	-0.04	1.22
	2014	2.30				

Source: Author's Analysis, 2015

The result of table 4.6 reveals that water surfaces has also witnessed decrease in its area coverage within the study periods (figure 4.8). It covers the least area compared to other landuses. Water bodies or water surfaces can be seen in rivers, ponds and streams within the study area. Table 4.6 shows that water bodies has witnessed decrease ($0.34km^2$) and an annual rate of loss (1.13%) between 2001 and 2014. This result described the fact that water ways are also part of the diminishing process as a result of an increased in urban landuse. This explained why some parts of southern part of Kaduna metropolis experiences seasonal flooding which have been narrowed down to buildings of residential houses along the water ways though there may be other factors responsible for its disappearance such as climate change etc. Most of the disappearance of water bodies also occurred during the crisis period of 2001 and 2014.

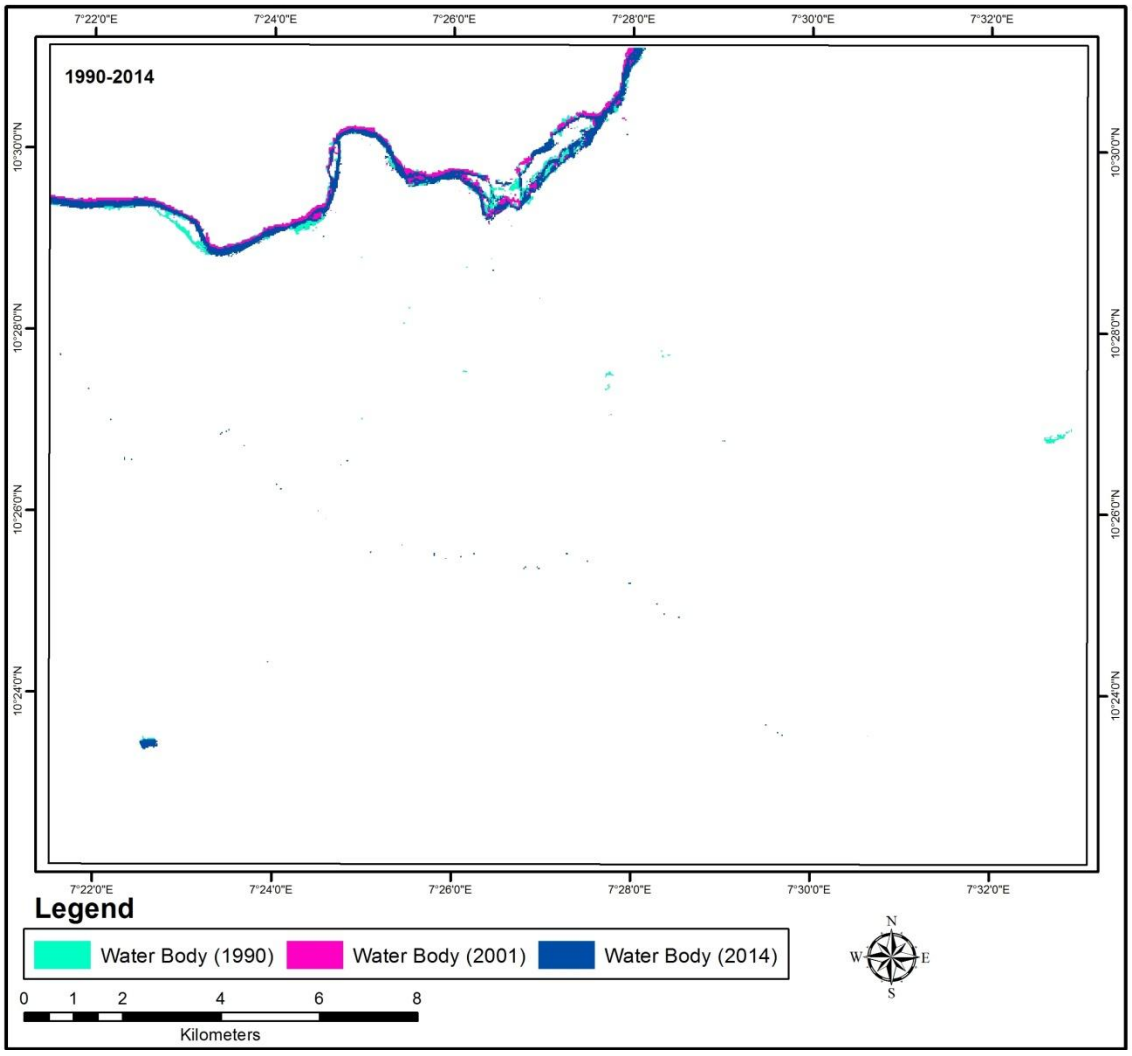

Figure 4.8: An overlay analysis showing the spatial changes (decrease) of water surfaces in 1990, 2001 and 2014

Source: Author's Analysis, 2014

4.4. THE EXTENT TO WHICH URBAN LANDUSE ENCROACHED INTO OTHER LANDUSES.

A clipping tool in ArcGIS 10.1 was used to determine how much of urban expansion encroached into other land uses within the study area. Urban expansion is basically referring to the areas that have developments on them and are collectively refer to built-up land or areas. In order to determine the extent of encroachment, an overlaid analysis was performed by overlaying the built-up areas on other landuses to determine the amount by which urban expansion encroached into other landuses.

Table 4.7 and figures 4.9, 4.10, 4.11 and 4.12 shows the extent of encroachment. This was achieved by using the generated landuse and land cover maps of 1990, 2001 and 2014 which served as a base maps and all the three time periods of urban expansion (1990, 2001 and 2014) were overlaid one after the other on all the landuse land cover maps. The area of the different landuses displaced by the urban expansion or built-up for the three time period is the encroachment. The rate of loss was obtained by dividing the amounts of landuses displace by the built-up land in each period by the total number of years between that period.

Table 4.7; Extent to which urban landuse encroached into other landuses.

Landuse	Extent of urban encroachment on other landuses in (km^2) from 1990-2014.	Annual rate of encroachment in (%) from 1990-2014.
Agricultural Landuse	62.27	13.83
Vegetated landuse	3.83	0.85
Bare landuse	8.21	1.82
Water Body	0.10	0.02
Total	74.41	16.52

Source: Author's Analysis, 2014

The analysis in table 4.7 reveals that agricultural land suffers the highest encroachment (62.27 km^2) from built-up land with an annual rate of encroachment (13.83%) between 1990 and 2014 (figure 4.9). While vegetated landuse was encroached by urban expansion (3.83km^2) with an annual rate of encroachment of 0.85% (figure 4.10). Similarly, bare surfaces were encroached (8.21km^2) by built-up land with an annual rate of encroachment of 1.82% (figure 4.11). Water body suffered the least encroachment (0.10km^2) with an annual rate of encroachment of 0.02% (figure 4.12).

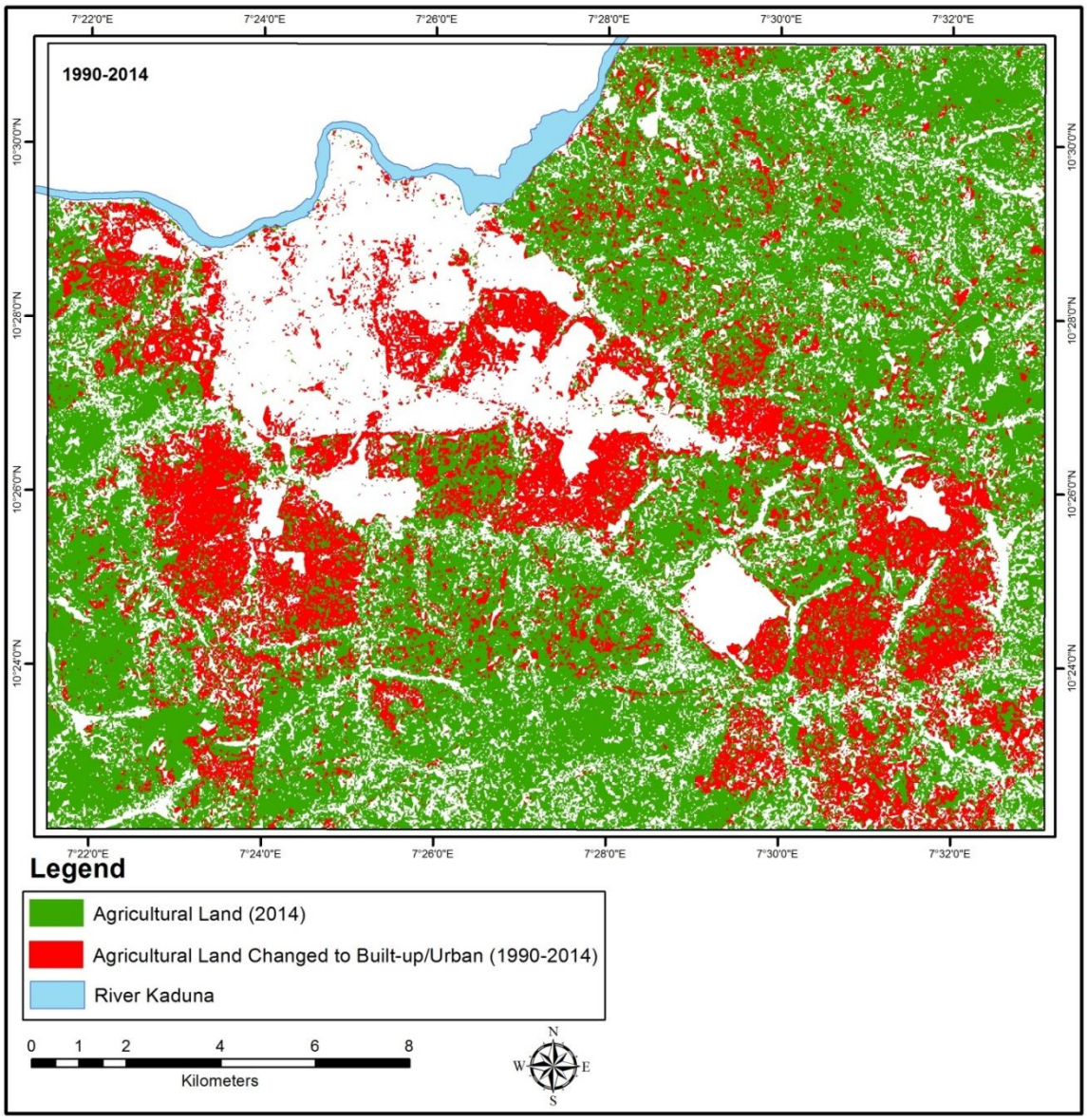

Figure 4.9: The extent to which urban landuse encroached into agricultural landuse from 1990 to 2014.

Source: Author's Analysis, 2014

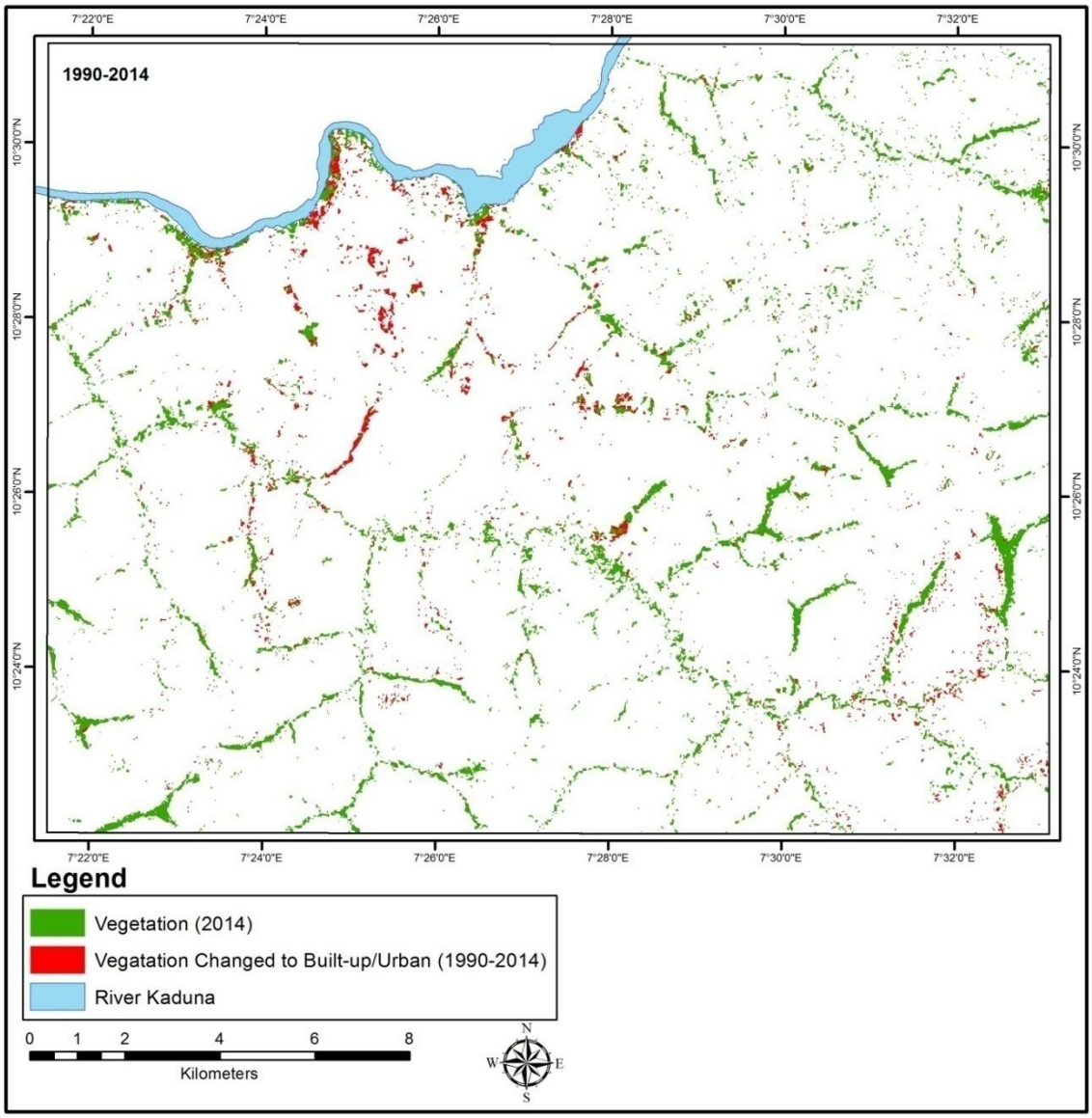

Figure 4.10: The extent to which urban landuse encroached into vegetated landuse from 1990 to 2014.

Source: Author's Analysis, 2014

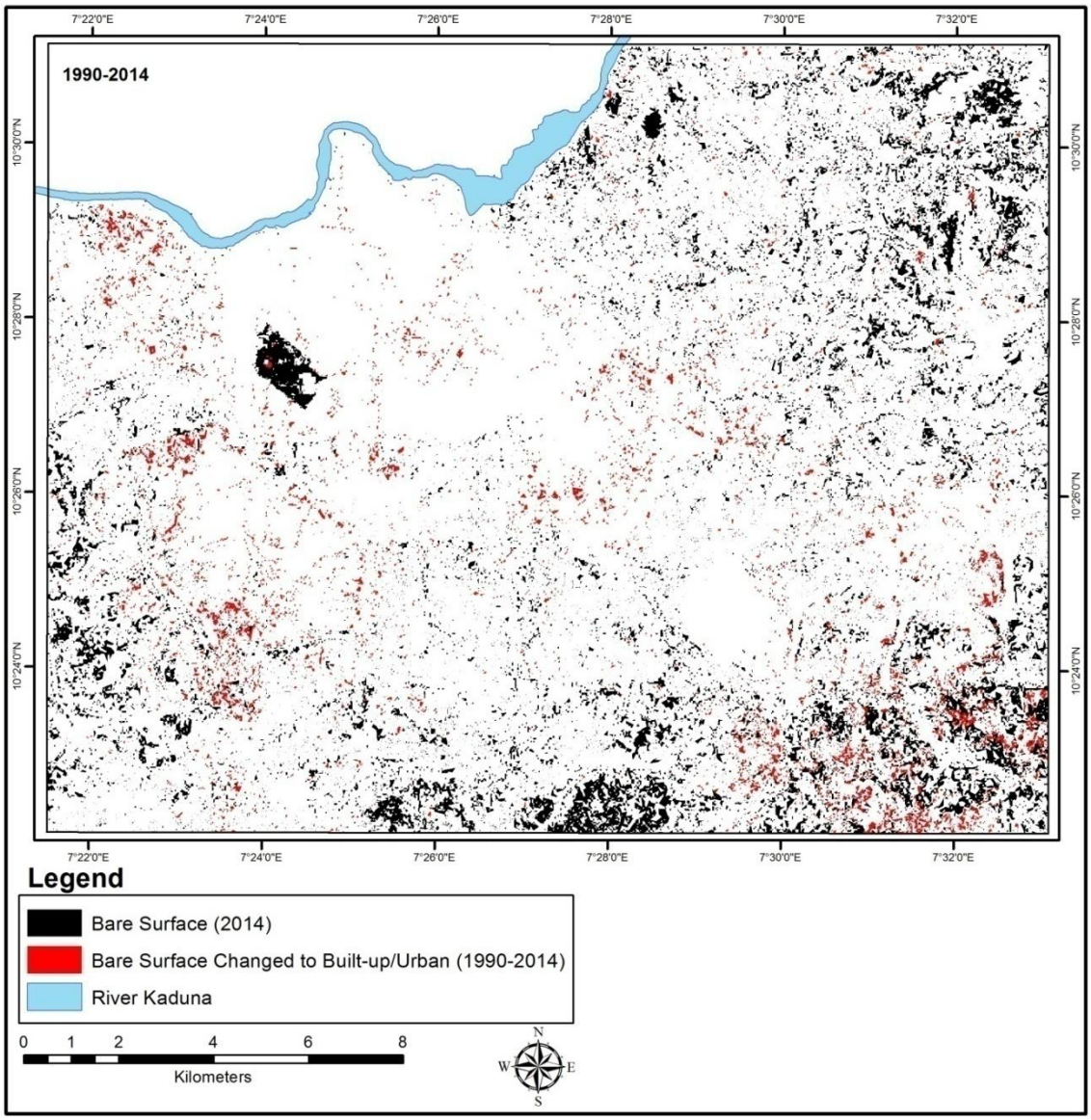

Figure 4.11: The extent to which urban landuse encroached into bare surfaces or landuse from 1990 to 2014.

Source: Author's Analysis, 2014

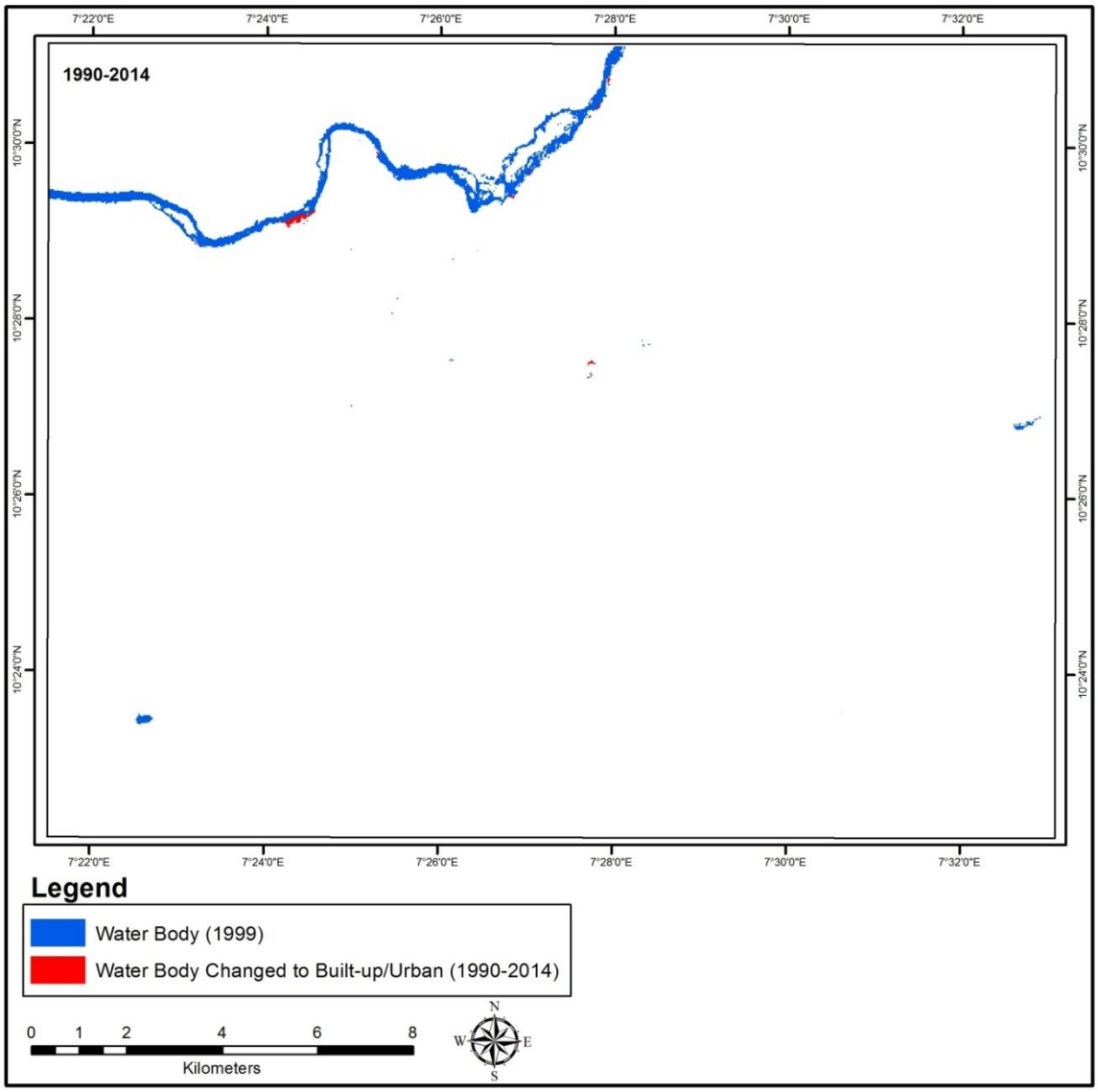

Figure 4.12: The extent to which urban landuse encroached into water surfaces to from 1990 to 2014.

Source: Author's Analysis, 2014.

4.5. Implication of urban expansion to the local farmers.

Urban expansion has its merits and demerits. However, the demerits are only considered here in relation to how urban expansion directly affects the local farmers who constitute a significant proportion of the population of the study area. It has been established that urban expansion encroaches more on agricultural land and since the farmers depends on agricultural land for their livelihood, the perception of the farmers with respect to loss of agricultural land was determined through the use of questionnaire. The data gathered was analysed using descriptive statistics as follows;

4.5.1. Sex distribution

The sex distribution of the respondents in Southern Part of Kaduna Metropolis (SPKM) is contained in figure 4.13.

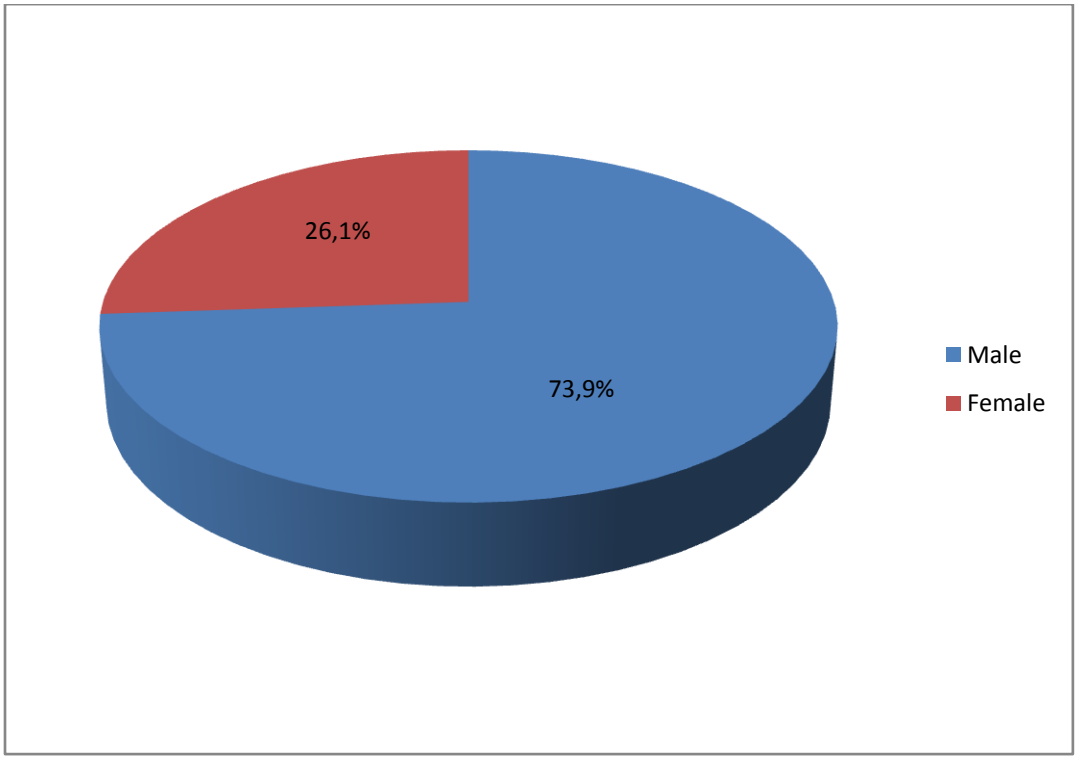

Figure 4.13; Sex distributions

Source : Field Survey, 2015

Figure 4.13 shows that majority of the respondents (73.9%) in southern part of Kaduna metropolis are male while 26.1% of the respondents are females.

4.5.2 Age structure of respondents.

The age structure of the respondents is shown in table 4.7.

Table 4.7: Age of Respondents

S/N	Ages	No. of Respondents	Percentages (%)
1	10 years below	4	1.3
2	11 – 20 years	45	14.1
3	21 – 30 years	86	26.9
4	31 – 40 years	107	33.4
5	41 – 50 years	41	12.8
6	51 – 60 years	24	7.5
7	60 years above	13	4.1

Source : Field Survey 2015

Table 4.7 shows that (1.3%) of the respondents in southern part of Kaduna metropolis are children from 10 years and below. 14.1% of the respondents teenage respondents who are between age bracket of 11 to 20 years. 26.9% of the respondents are young adults from the ages of 21 to 30 years. Majority (33.4%) are adult respondents from the ages of 31 to 40 years who are in a better condition to provide information as regards loss of farm lands and its implication. 12.8% are adult respondents between the mid ages of 41 to 50 years. The old respondents (51 – 60 years) constitute 7.5% While the very old who are from 60 years and above constitute 4.1% of the respondents.

4.5.3. Marital status of respondents

The marital status of the respondents is presented in table 4.8.

Table 4.8: Marital status of respondents

S/N	Status	No of Respondents	Percentage (%)
1	married	186	58.1
2	Single	76	23.6
3	Divorced/Separated	19	5.9
4	Widow/Widower	40	12.4
Total		320	100

Source : Field Survey 2015

Table 4.8 shows that majority (58.1%) of adult respondents in southern part of Kaduna metropolis are married. 23.6% are singles; 5.9% are divorced or separated while 12.4% constitutes widows and widowers.

4.5.4. Literacy level of respondents

The literacy level of respondents is shown in Figure 4.14.

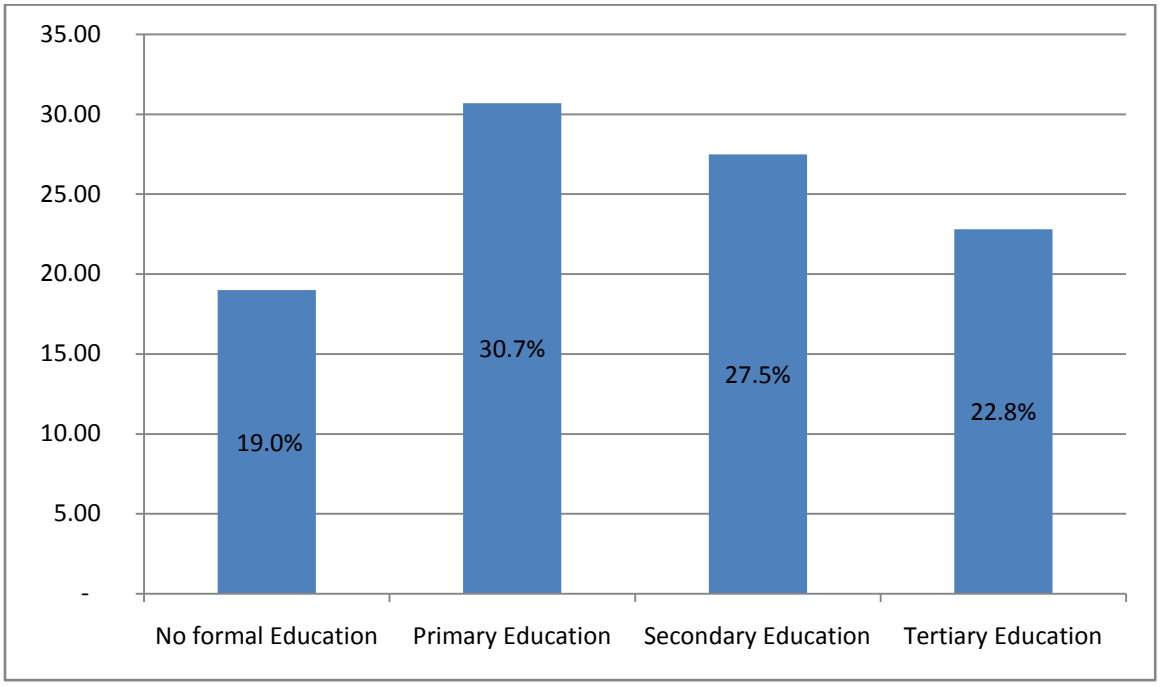

Figure 4.14: Level of Education in Southern part of Kaduna Metropolis

Source : Field Survey 2015

Figure 4.14 indicate that 81.0% of the adult respondents are literate in southern part of Kaduna metropolis against 19.0% who did not go to school. It further shows that about 30.7% of adult respondents have primary education in southern part of Kaduna metropolis. 27.5% have secondary education and only 22.8% of the respondents have tertiary education.

4.5.5. Duration of residence of respondents

The duration of stayed of respondents in SPKM is contained in table 4.9.

Table 4.9: Duration of stay of Residence

S/N	Duration of stay	No of Respondents	Percentage (%)
1	1 – 10 years	155	48.4
2	11 – 20 years	97	30.3
3	21 – 30 years	45	14.1
4	Over 30 years	23	7.2
TOTAL		320	100.

Source : Field Survey 2015

Table 4.9 shows that majority (48.4%) of the respondents of Southern Part of Kaduna Metropolis (SPKM) have stayed in this area only within the last 10 years; 30.3% between the last 11 to 20 years; 14.1% between 21 to 30 years. Only 7.2% have been in this area over the last 30 years.

4.5.6. Occupation of respondents

The respondents' occupation in SPKM is shown in table 4.10.

Table 4.10: Major occupation of Respondents

S/N	Occupation	No of Respondents	Percentage (%)
1	Only farming	30	9.3
3	Farming and Business/trade	113	35.2
4	Farming and Civil Servant a	81	25.4
5	Farming and Factory work	87	27.1
6	Artisans	10	3.0
Total		320	100.00

Source : Field Survey 2015

Table 4.10 shows that all the respondents practice agriculture and another occupation in southern part of Kaduna metropolis, except only 9.25% of the total respondents practice agriculture alone. More than quarter of the respondents (35.2%) practice both farming and business or trade. 25.4% practice both farming and civil service work. 27.1% of the respondents practice both farming and factory work. Only 3.0% practice agriculture and artisanship.

4.5.7. Sources of farmlands.

Source of farmlands of the respondents in SPKM is presented in table 4.11.

Table 4.11: Sources of farmlands

S/N	Source	No of Respondents	Percentage (%)
1	Inheritance	72	22.5
3	Lease (Rent)	173	54.1
4	Out-right Purchase	75	23.4
Total		320	100

Source : Field Survey 2015

Table 4.11 shows that 22.5% of farmlands in southern part of Kaduna metropolis are inherited, more than half of the farmlands (54.1%) are leased or rented and only 23.4% of the farmlands are obtained through out-right purchase.

4.5.8. Types of agricultural activities.

The type of agricultural activities of the respondents in SPKM is contained in table 4.12.

Table 4.12; Types of agricultural activities

S/N	Type of agricultural activity	No of Respondents	Percentage (%)
1	Crop production	129	40.3
3	Animal production	83	25.9
4	Both	108	33.8
	Total	320	100

Source : Field Survey 2015

Table 4.12 reveals that almost half of the farmers (40.3%) are involved in crop production in southern part of Kaduna metropolis. 25.9% of the respondents practiced only animal production, while, 33.8% practice both animal production and crop production.

4.5.9. Types of food crops produced.

Type of food crops produced by the respondents in SPKM is as shown in table 4.13.

Table 4.13; Types of Food Crops produced

S/N	Types of food crops produce	No of Respondents	Percentage (%)
1	Rice	33	10.2
3	Vegetables	17	5.3
4	Maize/Millet/Corn	147	45.8
5	Tubers	49	15.7
6	Both	74	23.0
Total		320	100

Source : Field Survey 2015

Table 4.13 shows that only 10.2% and 5.3% of the farmers in southern part of Kaduna metropolis are involved in rice and vegetable production respectively. This is as a result of limited Fadama lands which are suitable water logged lands that accounts for high yield in rice and vegetable production. Rice and vegetable farmlands are virtually situated along the banks of Kaduna River because of their water requirement where the lands are always moist and damped. Maize, Millet and Corn are the dominant crops in southern part of Kaduna metropolis and almost half of the respondents (45.8%) are involved. 15.7% of respondents produces Tubers and a total of 23.0% produces both the food crops.

4.5.10. Size of farmlands

Table 4.14 shows the sizes of the respondents' farmlands before 2002 and current size..

Table 4.14; Size of Farm lands before 2002/Current size

S/N	Size before 2002	No of Respondents	Percentage (%)	Current size	No of Respondents	Percentage (%)
1				0 hectares	115	35.9
2	< 5 hectare	160	50.0	< 5 hectares	101	31.6
3	6 – 10 hectares	81	25.3	6 – 10 hectares	46	14.4
4	11 – 15 hectares	44	13.8	11 – 15 hectares	32	10.0
5	16 – 20 hectares	24	7.5	16 – 20 hectares	19	5.9
6	20 > hectares	13	4.1	20 > hectares	7	2.1
Total		320	100.0		320	100.0

Source: Field Survey 2015

Table 4.14 shows that 115 (35.9%) of the respondents in southern part of Kaduna metropolis gave up their farming lifestyle as a result of a combination of factors ranging from loss of farm lands/reduction in farm lands, inadequate capital, lack of good seeds and lack of agro-chemicals etc. However, majority 205 (64.1%) of the respondents are still cultivating the remaining agricultural land; but however, admitted the prevalence of the above mentioned factors has cause a reduction in the number of hectare they cultivate before 2002. Of the 320 respondents who were all farmers before 2002, half of the respondents (160) representing (50.0%) were subsistence farmers who cultivates 5 hectares or less before 2002; currently dropped to more than quarter 101 (31.6%) who cultivates same 5 hectares or less. This could be due to the available farm land that was present in the area before 2002 before most of it underwent conversion into urban land. After 2002, the area started experiencing urban expansion which gradually continued eating up the agricultural land thereby resulting in a reduction in the overall agricultural land.

81 (25.3%) of the respondents who cultivates 6 to 10 hectares before 2002 now dropped to 46 (14.4%) who now cultivates 6 to 10 hectares. 44 (13.8%) of the respondents who cultivates 11 to 15 hectares before 2002 now currently dropped to 32 (10.0%) who cultivates the same number of hectares. 24 respondents (7.5%) who cultivates 16 to 20 hectares now dropped to 19 (5.9%). While 13 (4.1%) of the respondents who cultivates 20 hectares and above before 2002 now dropped to 7 representing (2.1%) who now cultivates 20 hectares and above.

4.5.11. Change in farm output

Proportion of respondents who affirmed farm output decrease or otherwise in SPKM is shown in figure 4.15.

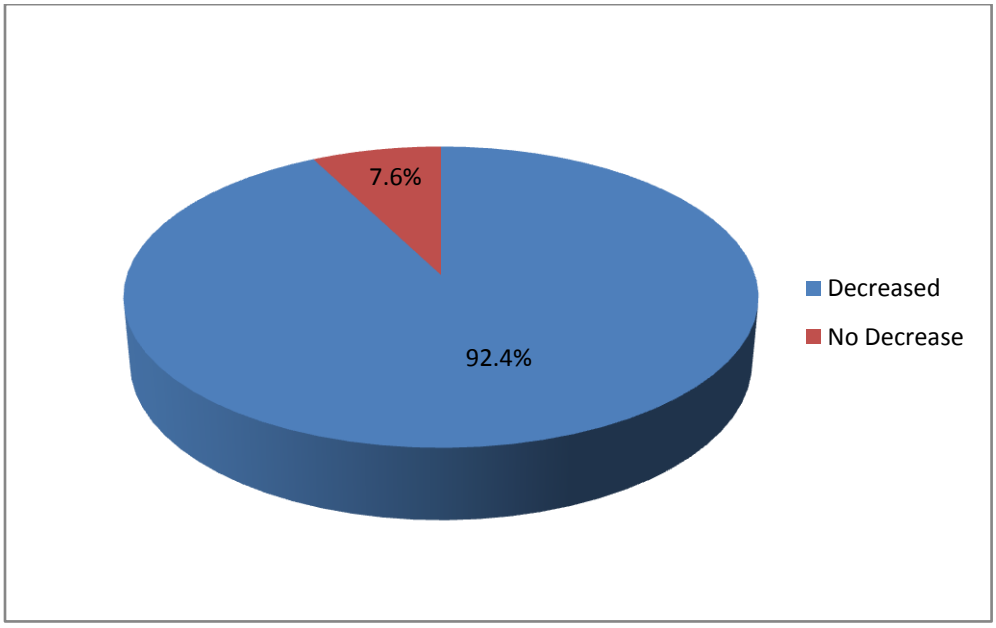

Figure 4.15: Proportion of respondents who affirmed farm output decrease or otherwise.

Figure: Field Survey 2015

Figure 4.15 shows majority of the respondents (92.4%) in southern part of Kaduna metropolis witnessed a decreased in their farm output as a result of a combination of factors ranging from farm land reduction, inadequate capital, lack viable good seeds and lack of agro-chemicals. Only a small proportion of the respondents (7.6%) witnessed an increased in their farm output due to perceived better condition. Some of them are commercial farmers who are government workers or into other businesses and use the money generated from such to support their farming business.

4.5.12. Reasons for decrease in farm output

The reasons for decrease in the farm output according to the respondents response is shown in table 4.15.

Table 4.15: Reason for decreased in farm output.

S/N	Reasons for reduction in farm output	No of Respondents	Percentage (%)
1	Inadequate capital	78	24.4
3	Lack of good seeds	12	3.8
4	Lack of agro-chemicals	15	4.7
5	Reduction in farmlands	100	31.1
6	Both	115	35.9
Total		320	100.0

Source : Field Survey 2015

Table 4.15 shows 24.4% of the respondents in southern part of Kaduna metropolis affirmed that inadequate capital was a factor that caused a reduction in their farm output. 3.8% said is lack of good seeds. 4.7% reveals that lack of agro-chemicals was a factor that caused a decrease in their farm output. More than quarter (31.1%) reveals that reduction in farmlands was the reason for the decreased in farm output since many of them are subsistence farmers who depend on local seeds and uses self labour. While, almost one third 115 (35.9%) of the respondents affirmed both factors are responsible for a decrease in their farm output.

4.5.13. Implication of loss in farmlands

The implication of loss of farmlands to the respondents is shown in table 4.16.

Table 4.16; Implication of loss in farmlands

S/N	Implication of the loss in farmlands to the farmers.	No of Respondents	Percentage (%)
1	Managing the remaining available farmlands.	50	15.6
3	Practice agriculture and government/factory work	155	48.4
4	Loss of livelihood	115	35.9
Total		320	100.0

Source : Field Survey 2015

Of the 205 respondents who still practice agricultural farming in southern part of Kaduna metropolis, table 4.16 shows 50 (15.6%) of the respondents are still managing the remaining available farm lands. 155 (48.4%) of the respondents practice agriculture and also working as government or factory workers in order to cushion the effect of farm lands reduction. While, 115 (35.9%) of the respondents who lost their source of farming livelihood resorted to other means of livelihood such as trading, weaving, tailoring, carpentry and other businesses etc.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents a summary of major findings, conclusion, recommendations and policy implementation of the study.

5.2 SUMMARY OF THE RESEARCH FINDINGS

This research analyse landuse and land cover change of southern part of Kaduna metropolis for a three time periods. i.e. between 1990 and 2001 and between 2001 and 2014 using GIS and Remote Sensing techniques. Digital image processing of Landsat 4 Thematic Mapper (TM) acquired in the 1990 ((spatial resolution 30m), Landsat 7 Enhanced Thematic Mapper Plus (ETM +) acquired in the 2001 (spatial resolution 30m) and Landsat 8 Enhanced Thematic Mapper Plus (ETM +) acquired in 2014 (spatial resolution 30m) were manipulated by Erdas Imagine version 9.2 and ArcGIS version 10.1 software package.

The results revealed the study area covers a total area of 319.16 km^2. It also revealed urban landuse witnessed a tremendous increase in its area coverage over the study periods while agricultural, vegetation, bare surfaces and water bodies witnessed a decrease in their area coverage. For instance, urban landuse occupied 12.71% of the total area in 1990; it later increased to 19.34% in 2001 and further increased to 36.38% in 2014. Therefore, urban landuse recorded an overall increase of 186.29% with an annual growth rate of 7.76% from 1990 to 2014. While agricultural land which is the most

dominant landuse occupied 66.99% of the total area in 1990, dropped to 63.03% in 2001 and further dropped to 49.81% in 2014. This shows an overall decrease of 25.64% with an annual decreased rate of 1.07% from 1990 to 2014. In a similar manner, vegetation landuse occupied a total land area of 8.79% in 1990, also decreased to 4.56% in 2014. This shows an overall decrease of 48.13% in vegetation landuse from 1990 to 2014. On the other hand, bare Surfaces which resurfaces in Sabon-Tasha and Maraban-Rido areas and other parts of the study area, occupied an observable land area of 10.50% in 1990 and slightly decreased to 8.52% in 2014. While water Body which had the lowest proportion of land coverage occupied 1.02% in 1990 and slightly decrease to 0.72% in 2014. The study also revealed that urban landuse is the major source of encroaching into other landuses and agricultural land suffers the greatest encroachment with an annual rate of encroachment (13.83%) between 1990 and 2014.

A socio-economic survey conducted to assess the perception of the farmers with respect to landuse and land cover changes in the study area revealed that 35.9% of the farmers have lost their means of livelihood and resorted to other means of livelihood as a result of landuse and land cover change. 15.6% are managing the remaining farm lands. While, 48.4% still practice agriculture and engaged into other work such as government/factory work.

5.3. CONCLUSION

This research work demonstrates the ability of GIS and Remote Sensing technique in capturing spatial-temporal data for analysing landuse and land cover change.

Land-use and land-cover change is evident in southern part of Kaduna metropolis as revealed by the analysis. All the landuses in the study area have change dramatically in the second period (2001 and 2014) from their original coverage. The main changes observed is increase in urban landuse (186.29%) between 1990 and 2014; and decrease in other landuses with agricultural landuse having the highest loss (13.83%) between 1990 and 2014. It was also established that most of the landuse and land cover changes are driven by human actions which in-turn affects man. The analysis of the results revealed that most of the landuse and land cover change took place during the 2001 and 2014 period, a period which coincided with a period when Kaduna metropolis experienced frequent civil and religious disturbances. The analysis also revealed that urban landuse is the leading course of encroachment into other landuses.

5.4. RECOMMENDATIONS

Having revealed by the study that landuse and land cover is evident in the study area; the following recommendations should be adhere to:.

1) There should be periodic Modelling of landuse and land cover changes for formulating effective environmental policies and management strategies.
2) Monitoring, control and evaluation of the LULCC of the area should be done regularly so as to checkmate the harp-hazard developments or modifications that may have negative consequences on the inhabitants.

3) Encouragement of building of vertical structures should be upheld by the relevant authorities in order to minimise the amount of urban landuse encroachment into other landuses.

5.5 POLICY IMPLICATION OF THE RESEARCH

Kaduna State Urban Planning Development Authority (KASUPDA) being a body charge with planning and enforcement of planning rules and regulations should be given the mandate to do their job without interference from any quarters; so as to curb unnecessary modifications that will results in further changes in the landscape.

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RESEARCH QUESTIONNAIRE

Topic: The impact of urban expansion on agricultural productivity in the southern part of Kaduna metropolis, Nigeria.

This questionnaire is designed to collect information on the above topic for M.Sc. Thesis in the department of Geography at the Ahmadu Bello University, Zaria. I therefore solicit your response and assistance in providing the requested information. I pledge that the information collected will be used for the purpose of this research alone and will not be passed to a third party without your authorization.

Ishaya Goje Musa.
M.Sc. Research student,
Department of Geography,
Ahmadu Bello University, Zaria.

Please, tick where appropriate.

SECTION A: LOCATION

Name of locality: .....

Name of residential neighbourhood: .....

SECTION B: SOCIO-DEMOGRAGRAPHIC CHARACTERISTICS

1. Sex: i. Male [ ] ii. Female [ ]
2. Age: i. 15years and below [ ] ii. 16 – 30 years [ ] iii. 31 – 45 years [ ] iv. 46 years and above.

3. Marital Status: i. Single [ ] ii. Married [ ] iii. Divorced [ ] iv. Separated [ ]
4. What level of Education have you attained?

   i. Primary [ ] ii. Secondary [ ] iii. Tertiary [ ] iv. Non formal [ ]

SECTION C: INFORMATION ON IMPLICATION AND LOST IN FARMLANDS TO THE FARMERS.

5. How long have you lived in this area?

   i. Last 1 – 10 years [ ] ii. Last 11 – 20 years [ ] iii. Last 21 – 30 years [ ] iv. Over last 30 years.

6. What is your main occupation?

   i. Only farming [ ] ii. [ ] iii. Business and farming [ ] iv. Civil servant and farming [ ] v. Factory worker and farming [ ]

7. If farming, what is the source of your farmland?

   i. Inheritance [ ] ii. Lease (Rent) [ ] iii. Out-right purchase [ ]

8. What type of agricultural activity do you practice?

   i. Crop production [ ] ii. Animal production [ ] iii. Both [ ]

9. If crop production, what type of food crops do you produce?

   i. Maize [ ] ii. Millet [ ] iii. Rice [ ] iv. Tubers [ ] v. Vegetables [ ]

10. What was the size of your farmland before 2002?

    i. 0 - 5 hectares [ ] ii. 6 - 10 hectares [ ] iii. 11- 15 hectares [ ] iv. 16-20 hectares [ ] v. 20 and above hectares [ ]

11. What is the present size of your farmland?

i. 0 - 5 hectares [ ] ii. 6 - 10 hectares [ ] iii. 11- 15 hectares [ ]

iv. 16-20 hectares [ ] v. 20 and above hectares [ ]

12. If plot reduce, why? .....

13. Between these periods, has your farm output decreased? i. Yes [ ] ii. No [ ]

14. If yes, what are the reasons?

i. Reduction in farmlands [ ] ii. Inadequate capital [ ] iii. Lack of good seeds [ ]. iv. Lack of agro-chemicals [ ] v. Both [ ]

15. How has the loss in farmlands affected your farming lifestyle?

i. Still managing the remaining available farmlands [ ]

ii. Resort to other means of livelihood as a result of loss in livelihood [ ]

iii. Others (Spacify) .....

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Thank you